The Hammer-Beam Roof: Tradition, Innovation and the Carpenter's Art in Late Medieval England

Robert Beech

A thesis submitted to the University of Birmingham
for the degree of DOCTOR OF PHILOSOPHY

Department of Art History, Film and Visual Studies
College of Arts and Law
University of Birmingham

September 2014

ABSTRACT

This thesis is about late medieval carpenters, their techniques and their art, and about the structure that became the fusion of their technical virtuosity and artistic creativity: the hammer-beam roof. The structural nature and origin of the hammer-beam roof is discussed, and it is argued that, although invented in the late thirteenth century, during the fourteenth century the hammer-beam roof became a developmental dead-end. In the early fifteenth century the hammer-beam roof suddenly blossomed into hundreds of structures of great technical proficiency and aesthetic acumen. The thesis assesses the role of the hammer-beam roof of Westminster Hall as the catalyst to such renewed enthusiasm. This structure is analysed and discussed in detail. Its place in the milieu of late medieval architecture is assessed, and its influence evaluated. That influence took effect mainly in East Anglia. Thus, early fifteenth-century trends in hammer-beam carpentry in the region are isolated and analysed. A typology of is created, from which arise surprising conclusions regarding the differing priorities late-medieval carpenters ascribed to structure, form and ornament. A chapter is also devoted to a critical review of literature pertaining to the topic.

ACKNOWLEDGEMENTS

Invaluable help was provided during the research of this thesis for which thanks is due (with sincere apologies for any omissions).

The following kindly showed me round buildings and roof-spaces not normally accessible to the public:

> The Abbots' Hall, Westminster: David Risley.
> Bishop's Kitchen, Bishop's Palace, Chichester: Revd. Canon Ian Gibson.
> Chichester Cathedral: Ralph Tyreman, Clerk of Works.
> Ford Church, Shropshire, Elvire Mortimer.
> Lambeth Palace: Amy Wilson, Events and Tours Manager.
> The Pilgrims' Hall, Winchester: Angela Slater, School Secretary.
> Salisbury Cathedral: Gary Price, Clerk of Works, and Richard Pike, Head Carpenter.
> Westminster Hall: Dr Mark Collins, Estates Archivist & Historian.
> York Minster: Rebecca Thompson, Superintendent of Works, and Paul Greene, Building and Services Manager.

Notwithstanding our tussles over grammar and word choice, thanks are due to my PhD supervisor David Hemsoll for his positive words and criticism.

Traditional carpenters Chris Dalton, Rick Lewis and Ed Crane gave advice on technical matters (although I should add they do not necessarily agree with all my conclusions). Chris's craftsmanship rendered my Westminster Hall reconstruction considerably less baffling, indeed, possible. Rick and wife Sally supplied food and lodging (and drink) during my Suffolk travels; Sally encouraged me to learn 'Sketchup.'

Also thanks to the many churchwardens and key-holders who, in order to view their splendid roofs, allowed me to turn many a giant key in many a rusty lock; to Julie Hawkes at the Museum of London for hauling out the Westminster Hall wall post; Graeme Beamish, and Nick Molyneux of English Heritage, for their comments on Idlicote Church; Gerald Steer for confirming the grisly fate of Balle's Place; John Walker for photographs, and particularly his drawings of Tiptofts; the staff at the Suffolk and Warwickshire Record Offices for their patience during my fruitless searches there. The following architects supplied drawings: Ruth Blackman sent me her wonderful drawings of the roof at Beeston-next-Mileham; Stuart Page supplied crucial drawings of Ightham Mote. Further miscellaneous nuggets of information were supplied by, John Clark, Dorothy Treasure, Joe Thompson, Dr David Yeomans and Dr Martin Bridge. Evire Mortimer was initially encouraging - and then sympathetic - towards my thwarted attempt to get Ford Church tree-ring dated, and, although ultimately not taken up, I thank the College of Arts and Law for the offer of a research grant towards this project. I also thank Madge Moran for her visit to Ford and her subsequent comments.

Finally, thank you to Sonia Ritter, for her cheerful disposition, unflagging encouragement, and willingness to read and comment upon material well beyond her field of expertise.

The Hammer-Beam Roof: Tradition, Innovation and the Carpenter's Art in Late Medieval England

CONTENTS

PREFACE

A Note on Carpentry Terms and Taxonomy

The study of medieval roof carpentry is often rendered opaque by excessive scrutiny of its minutiae and taxonomical pedantry. Nevertheless, certain concepts and terms need to be grasped. In the Middle Ages British carpentry achieved a level of technical competence and artistic expression that has never been equalled. Yet until recent decades academia largely ignored the field. Scholars adept at discussing the nuances of a *mouchette* or a *tas-de-charge* in masonry structures would have had difficulty identifying the most basic component in a coeval timber roof. While advances have been made, the study of medieval timber roofs remains a specialised field. I recommend, therefore, that the reader refer frequently to my illustrated glossary. The glossaries in later editions of Pevsner's *The Buildings of England* series also contain diagrams of roof-types and their components. The Council for British Archaeology's *Recording Timber Buildings: An Illustrated Glossary* (1996), while some of its terms remain contestable, is essential. Highly recommended is R.W. Brunskill's *Timber Building in Britain* (2007).

Note on dates

A date thus: '1427d'; 'd' signifies that the structure has been dated by dendrochronology. Tree-ring dates are taken from the Archaeology Data Service Dendrochronology Database and *Vernacular Architecture*.

ABBREVIATIONS

AC : *Age of Chivalry: Art in Plantagenet England 1200-1400*, eds. Jonathan Alexander & Paul Binski (London: Royal Academy of Arts, 1987)

ADSDD: The Archaeology Data Service Dendrochronology Database.

CBA: Council for British Archaeology, specifically, N. W. Alcock et al., *Recording Timber-Framed Buildings: an Illustrated Glossary* (York: Council for British Archaeology, 1996)

DNB : *Oxford Dictionary of National Biography*, Oxford University Press, 2004; online ed., Jan 2009 <http://www.oxforddnb.com>

EH: English Heritage

EHC : Cecil A. Hewett, *English Historic Carpentry* (Fresno, Ca.: Linden, 1997)

NHLE : English Heritage: 'National Heritage List for England', 2014 <www.english-heritage.org.uk>

EMA : John Harvey, *English Medieval Architects* (Gloucester: Alan Sutton, revised ed., 1984)

HKW : H. M. Colvin et al. (eds.), *The History of the King's Works,* Vols. 1 & 2, *The Middle Ages* (London: HMSO, 1963)

NA : National Archives

RCHME: Royal Commission Historic on Monuments (England), various regional and metropolitan volumes (London: HMSO)

Salzman: L. F. Salzman, *Building in England Down to 1540* (Oxford, OUP, 1952)

VA: *Vernacular Architecture*

VCH: *Victoria County History,* various county volumes.

WC: *The Westminster Chronicle*, ed. & trans. L. C. Hector and Barbara F. Harvey (Oxford: Clarendon Press, 1982)

THE HAMMER-BEAM ROOF: TRADITION, INNOVATION AND THE CARPENTER'S ART IN LATE MEDIEVAL ENGLAND

INTRODUCTION

This PhD is about the ostensibly prosaic subject of carpentry and carpenters. Specifically it is about the metier of craftsmen during the golden age of English carpentry in the fourteenth and fifteenth centuries and the pinnacle of their achievement: the hammer-beam roof. The literature on gothic architecture is vast, but in such studies the work of the carpenter has always been the poor cousin of the more obvious skills of the mason. Yet without the ingenuity of the carpenter, the architectural and engineering feats of the Middle Ages could never have been accomplished. The hammer-beam roof, the apogee of which is in Richard II's Westminster Hall (designed by Hugh Herland; begun 1393), is the unsurpassed high watermark of that ingenuity. Further, the hammer-beam roof is not only a great technical achievement. At its best, it is a form that can display an aesthetic sensibility of both subtle refinement and sublime grandeur. To walk into an edifice such as Westminster Hall, or even a village church such as St Mary's, Woolpit in Suffolk, is to have one's eyes drawn aloft in wonder, not only at the technical achievement, but at the artist's vision.

Academic literature on medieval carpentry is relatively limited, surprisingly contentious and sometimes flawed. A multidisciplinary field - of necessity encompassing the work of archaeologists, medieval historians, structural engineers, architects and art historians - published research is often dogged by obsessive concentration on minutiae or interdisciplinary arrogance. The field cries out for a more collaborative approach. My thesis attempts to knit some of those sometimes divergent interdisciplinary strands together. Focussing on of the hammer-beam roof, a peculiarly British phenomenon, I set out to trace its development, from rudimentary beginnings in the late thirteenth to its full flowering the early fifteenth century. I address not only the technical details of *what* happened, but also more panoramic questions as to *why*. Thus, my thesis places the hammer-beam in the context of its fourteenth-century architectural milieu. It examines the sometimes conflicting perspectives of client demand and contemporary carpenter 'know-how', a craft rooted in tradition but spurred to innovate by new aesthetic trends and technical challenges.

Research Methodology

I have personally examined all the buildings on which I write in any depth. I have photographed all of them in detail and made extensive notes. Of a large proportion I have made a more thorough survey, and I designed a checklist to aid the process. A completed example is illustrated in Appendix 1.

The first third or so of my PhD relies principally – but not exclusively - on secondary literature. I have, however, approached this material in a way that has yielded original work. For example, I am not aware of the existence in published literature of anything similar to my opening chapter elucidating the carpenter's role and centrality in the development of medieval architecture.

Any investigation of hammer-beam roofs must acknowledge, indeed celebrate, the roof of Westminster Hall, and with regard to this remarkable structure my research has followed two main strands. (1) I have studied in depth the detailed drawings prepared by HM Office of Works under the aegis of the architect Frank Baines prior to the roof's repair commencing in 1914. The published *Report ... On the Condition of the Roof Timbers of Westminster Hall* (1914) presented to Parliament has been well studied. All of the secondary literature on the roof refers to the *Report* and many include copies of Baines's completed drawings. Unknown, until Lynn Courtenay's introductory 1990 paper, 'The Westminster Hall Roof: A New Archaeological Source,' were the Office of Work's 'Schedules' held in the National Archives. These unpublished preparatory drawings made by the Office prior to the publication of the *Report* are far more detailed and extensive, but they are still little-known. My study of the 'Schedules' has led to the second strand of my Westminster Hall research: (2) a 1:4 reconstruction of a key component of the roof, the lower hammer-beam bracket, using identical jointing techniques to those of Herland. This process has led to a greater understanding of late-fourteenth century carpentry practice, and provided an insight into the deliberations of the carpenter as he attempted the unprecedented structure.

Westminster Hall apart, my research has taken me into the heartland of hammer-beam construction: East Anglia. These structures were built by craftsmen and commissioned by patrons who left little or no documentary record. Where possible I have consulted the scarce contemporary accounts that survive, for instance bequests and churchwardens' accounts. Such records, however, are of limited use, and my main source material has been the buildings themselves. Having isolated a limited number of hammer-beams constructed in the first third of the fifteenth century, I have surveyed these in order to trace developments in hammer-beam structure, form and ornament, and late-medieval carpentry practice.

Objectives and Structure

I now set out the key points made in this thesis:

- The carpenter was central to all medieval building both as technician and artist.
- The hammer-beam roof was the carpenter's ultimate expression of both technical ability and artistic creativity.
- The hammer-beam evolved from two discrete structural nodes; one became a cramped developmental cul-de-sac; the other a broad avenue of varied and complex forms.
- Westminster Hall was the fulcrum upon which hammer-beam construction tipped: from scarce and bucolic to abundant and splendid.
- From secular Westminster Hall, East Anglian carpenters seized upon and then developed primarily visual ideas for sacred ends.

- Following the lead of Westminster, carpenters ascribed surprising priorities to form, ornament and structure.
- Ultimately my research answers the question of why what appeared to be a developmental dead-end in the fourteenth century led in the fifteenth to some of the most outstanding (if underrated) works of art in the English medieval canon.

To expound these points I have structured my thesis as follows. The title of Chapter 1, 'Why the Work of the Medieval Carpenter is Worthy of Study', is exoteric. I further answer why for centuries the work of the carpenter was largely ignored by scholars. The centrality of the carpenter to all medieval building is considered, and also the nature and variety of his work. I conclude the carpenter to be consummate, both as an engineer and artist. Chapter 2, 'Truth, Falsehood and Pendant Posts …' establishes basic definitions and thesis parameters. The process proves thornier than one may imagine. The field of carpentry studies is plagued by apodictic judgement and obsession with component taxonomy, here displayed in the debate surrounding 'true' and 'false' hammer-beam roofs. These are considered; some are dismissed as irrelevant, and the chapter forms a determinative foundation from which the rest of the thesis may proceed. Chapter 3 is a review of scholarly literature pertaining to hammer-beam roof development. Although by the end of the first decade of the twenty-first century the literature on medieval carpentry has become fairly extensive, scholarship relating directly to hammer-beams is sparse and of uneven quality. This literature, dating from the mid-nineteenth century to the latter decades of the twentieth, is critically assessed. Chapter 3 debunks scholarly assertions regarding the structural antecedents of hammer-beam roofs, so in Chapter 4, 'Structural Precursors and Fourteenth-century Developments', I propose some of my own structural embryos. Fourteenth-century developments are evaluated, including examining the debate concerning just which was the earliest hammer-beam structure. I go on to argue that fourteenth-century hammer-beam construction proved to be a structural and ornamental dead-end.

Chapter 5, 'Westminster Hall 1099-1393', initiates my analysis of the pivotal roof in the history of hammer-beam development, a structure which was to have far-reaching effects on fifteenth-century display carpentry. I consider the function of Westminster Hall, why Richard II radically remodelled it, and the consequent demands and constraints Richard's desires placed upon the carpenter / designer Hugh Herland. Chapter 6 is an analysis of the carpentry of Westminster Hall. Herland's roof is *the* most analysed example of medieval English carpentry. Art historians, architects, archaeologists and engineers have argued about how the roof performs structurally, with no consensus reached. I summarise these debates and introduce a hitherto neglected perspective: that of the carpenter. Investigated is, not how the roof performs now as judged by modern-day critics, but how Herland *thought* it would perform in 1393. This task is accomplished by the use of two original sources: (1) the examination of unpublished drawings of the roof prepared by HM Office of Works in 1913, and (2) my own 1:4 reconstruction of the lower hammer-beam bracket. Evidence is also presented that Herland was groping towards solutions to the enormous technical challenge of the roof by examining carpentry he completed prior to the commission. I arrive at some surprising conclusions regarding the differing priorities Herland assigned to structure and form. Continuing the theme of Westminster Hall, Chapter 7, 'Architectural Contexts and Stimuli …', examines broader developments in late fourteenth-century architecture, and places Herland's roof in the context of other high-status works. I specifically analyse trends in carpentry and identify formal motifs which Herland may have drawn on to inform his masterwork. Duplicity was also integral to the Westminster design, and I identify earlier examples of this ethos.

The detailed discussion of Westminster Hall concluded, in Chapter 8 I turn my attention to the fifteenth-century development of hammer-beam roofs. From a handful of mainly crude and unprepossessing fourteenth-century examples, the hammer-beam suddenly blossomed into hundreds of structures of great sophistication and splendour. I propose that the ethos behind Westminster Hall drove this spread, if not in structure, then in form and ornament. These developments took place mainly in East Anglia. I identify early examples of hammer-beam roofs in the region, establish a typology, and consider technical, formal and ornamental trends contained therein. Discovered again is a metier of carpentry with unexpected priorities vis-à-vis the conflict of form and ornament with structural stability.

Chapter 1

WHY THE WORK OF THE MEDIEVAL CARPENTER IS WORTHY OF STUDY

Throughout history, the carpenter and his work has been accorded little merit. This chapter is an apologia for the validity of the topic of medieval carpentry as an academic subject. To develop the theme, I consider the work of carpenters in context with that of the more celebrated mason from two perspectives: the carpenter as an engineer, and the carpenter as an artist.[1] By considering some neglected aspects of their work, I examine innovative engineering solutions to increasingly demanding technical challenges. I then appraise the carpenter's role as an artist and his impact on aesthetic trends in late medieval architecture, to discover that some significant conclusions can be drawn regarding the priorities assigned to the conflicting demands of form, ornament and structure. In short, this chapter is an evaluation of the carpenter's contribution to the canon of late-medieval architecture.

CARPENTERS' STATUS: PROFESSIONAL, POPULAR AND ACADEMIC PERSPECTIVES.

'*Amonge alle the craftys of the worlde of mannes crafte masonry hath the moste notabilite*'

A late fourteenth-century masonic manual[2]

[1] A note on my use of the word 'artist': In contrast to the mason, carpenters have been virtually excluded from academic discussions of medieval art. Nonetheless, as will be argued, carpenters deserve to be considered in this context on account of their extraordinary creativity and sophisticated thought processes. This, of course, is a retrospective view. These craftsmen would have had no concept of themselves as artists in any post-Renaissance 'liberal' sense.

[2] D. Knoop et al. (eds.), *The Two Earliest Masonic Mss* [The Cooke Manuscript, c. 1390-1410, and The Regius Manuscript, c.1390] (Manchester: University of Manchester, 1938), 'The Cooke Manuscript', 130-135. For a analysis and interpretation of the texts see Lisa H. Cooper, *Artisans and Narrative Craft in Late Medieval*

Those who have worked in the construction industry are familiar with inter-craft rivalry. 'A chippy is a bricky with his brains bashed out' is a common refrain whose nouns may be reversed according to the profession of the speaker, and the above declaration from a late fourteenth-century masonic manual illustrates that the practice is not new. The statement displays a masonic conception of other medieval construction skills, including those of the carpenter, as belonging to a lower level of some artisanal pecking-order. Indeed, throughout the manual the author is concerned with elevating the intellectual status of the mason. He establishes his writings as merely the latest in a legacy of scholarly works on the topic of masonry dating back to ancient times. Further, to add to the highbrow textual pedigree, he repeats that 'the sciens of gemetry' is fundamental to the art of masonry, relating that masonry had its genesis in the geometry of Euclid.[3] Befitting such illustrious roots, geometry was one of the quadrivium of liberal, 'divine', arts taught to nascent scholars at universities during the Middle Ages. The mason, then, recommends himself as no mere mechanic in the manner of lesser craftsmen such as carpenters, but as an intellectual, a practitioner of the liberal arts.[4]

England (Cambridge: CUP, 2011), 56-82. The texts, forms of *apologia* for masonry, have no equivalents in carpentry as far as I am aware. The earliest known carpentry manuals belong to the seventeenth century, and they are just that: design manuals with no intellectual pretentions. For example, Godfrey Richards, *The First Book of Architecture by Andrea Palladio; translated out of Italian: with an appendix touching doors and windows … ; Also rules and demonstrations, with several designs for the framing of any manner of roofs either above pitch or under pitch, whether square or bevel …* (London: Printed by J.M. and sold by G. Richards and by Sam. Thomson 2nd ed., 1668), contains the addendum, 'The Rules of Roofs', by William Pope ('ingenious architect', committee member of the Company of Carpenters); Joseph Moxon, *Mechanick Exercises, or the Doctrine of Handy-works,* published in monthly instalments from 1678 onwards; published in a single volume, (London: 1703).

[3] Knoop et al., 31.

[4] Opinions of artisans from the aristocracy of the ancient world: Aristotle, 'there work is bad, and there is no connection with virtue in the work to which the mass of artisans … put their hand', 'in the city that is governed in the finest way … the citizens must not live the life of a vulgar craftsman … For such a life is ignoble and contrary to virtue': *Politics* VI, 4, 1319 a 26-28; *Politics* VII, 9, 1328 b 37-40. Cicero: 'All mechanics are engaged in vulgar trades; for no workshop can have anything liberal about it', *De officiis*, I, xlii. Thomas Aquinas: 'common (i.e. the lowest) artisans who get dirty from their work … cannot be citizens in the best organised political community,' *Commentary on Aristotle's Politics*, trans. Richard J. Regan (Indianapolis, Ind.: Hackett; Lancaster: Gazelle Drake Academic, 2007). See also Elspeth Whitney, *Paradise Restored: the Mechanical Arts from Antiquity through the Thirteenth Century* (Philadelphia: American Philosophical Society, 1990), 75-127, for the philosophical reappraisal of the mechanical arts in the twelfth and thirteenth centuries, and Lisa H. Cooper, 7-9, for shifting attitudes towards artisans during the medieval period.

In a similar vein, William Harrison (1535-93), in his contemporary account of Tudor life, provides a more popular view of the carpenter. He reports that, 'the ancient manors and houses of our gentlemen are … for the most part, of strong timber, in framing whereof our carpenters have been, and are, worthily preferred before those of like science among all other nations.' Nonetheless, despite such coveted ability, he observes that carpenters were of lowly status, 'the common sort of artificers', and assigns them the status of day-labourers.[5] This popular and professional opinion was mirrored in medieval graphic art. Almost invariably when major building works were depicted in illustrations, the masons dominate the composition. The carpenter is often excluded entirely, and when depicted, shown representationally as an axe-wielding hewer of logs (Figs 1.1-1.3).

Perhaps it was the prosaic and abundant nature of much of their work that prompted such disparagement. The overwhelming majority of buildings throughout the medieval period were of timber. Carpenters were ubiquitous and numerous in England, as the prevalence of the surname 'Wright' attests.[6] The most prestigious buildings, especially in the later medieval period, were of stone, ostensibly products of the 'wittys and cunnyng' of the mason.[7] And although, as we shall see, the carpenter played a key role in the construction of these magnificent structures, his quotidian work was commonplace and lacked the singularity of masonry buildings.

This perception of the carpenter as a less creditable craftsman than the mason continued down through the ages and was reflected in later studies of medieval architecture. When, after centuries of indifference and contempt, appreciation of medieval architecture was re-awakened in Britain in the eighteenth and nineteenth centuries, it was the work of the mason that attracted antiquarian investigation. The ensuing literature of the period, much of it in the early nineteenth century the result of

---

[5] William Harrison, *The Description of England*, 1577, ed. G. Edelen (New York / Washington: Dover Publications / Folger Shakespeare Library, 1994), 199, 117-118, also 276, 277.

[6] See below. *The Wryght's Chaste Wife*, and C. F. Innocent, *The Development of English Building Construction* (Newton Abbot: David & Charles, 1971; [first published CUP, 1916]), 91-2, for the synonymity of 'wright' with 'carpenter' in the Middle Ages.

[7] Cooke Manuscript, 15-25.

the efforts of the publisher John Britton, is full of lavishly detailed illustrations. Mouldings, cornices, corbels, crockets and capitals are all lovingly measured and drawn to scale. Pages of florid text are devoted to the description of structures and their detailing. But the features depicted and described are almost invariably of masonry. J. H. Parker was Britton's cultural successor as publisher of works on Gothic architecture, proclaiming in his preface to *The Ecclesiastical and Architectural Topography of England: Suffolk* (1855) that 'the study of Gothic Architecture is … a necessary branch of polite education.'[8] Suffolk is a county abundant in extraordinary late medieval carpentry. Its famous 'angel' hammer-beam roofs display a carpentry tradition in which prodigious technical ability is matched to a discriminating aesthetic acumen. Yet Parker's *Suffolk* neither discusses nor depicts a single work of carpentry. The words of John Robison, in an early work on structural theory as it pertained to roof carpentry, encapsulate such indifference and disdain: 'The principles of masonry, and not of carpentry, should be seen in our architecture, if we would have it according to the rules of good taste.'[9]

Such dearth of interest had already been bemoaned by Britton. In his *Dictionary of the Architecture and Archaeology of the Middle Ages* (1838) he commented, 'The gradual progress in the art of building with timber is a subject of which a judicious account is a desideratum.'[10] Britton's plea went unheeded, however, and want of interest in the work of the carpenter prevailed until the latter decades of the twentieth century.[11]

---

[8] *The Ecclesiastical and Architectural Topography of England: Suffolk* (Oxford: J.H. & J. Parker, 1855) is un-paginated.

[9] John Robison & Thomas Tredgold, *A Rudimentary Treatise on the Principles of Construction in the Carpentry and Joinery of Roofs*, (London: John Weale, 1859), 9. Similar opinion is expressed by Thomas Morris: 'I have spoken of mason and carpenter as in a sort of opposition, but their respective pretensions may be considered; and the mason is entitled to precedence', 3.

[10] John Britton, *Dictionary of the Architecture and Archaeology of the Middle Ages* (London: The author; Longman, Orme, Brown, Green and Longmans, 1838), 461.

[11] There were 'voice[s] crying out in the wilderness' (John 1: 23) during this period. The most notable are: Raphael & J. Arthur Brandon, *The Open Timber Roofs of the Middle Ages* (London: 1849), George Edmund Street's lecture to RIBA in 1864, 'On English Woodwork in the Thirteenth and Fourteenth Centuries', (recorded in, *RIBA Transactions,* 1st series, Vol. 14, 1864/1865, pp. 85-108), and the Victorian architect Thomas Morris's *Brief Chapters on British Carpentry: History and Principles of Gothic Roofs* (London: Simpkin, Marshall & Co., 1871). Further, due to intermittent restoration projects and allied debate, interest in the hammer-beam roof of Westminster Hall simmered throughout the century (discussed later in this thesis). The

The words of Geoffrey Webb in his survey for The Pelican History of Art series, *Architecture in Britain: The Middle Ages* (1956), the standard work on the subject in the mid-twentieth century, echo those of Britton: 'Further study of the very elusive evidence of early timber building is one of the tasks which is crying out for the attention of architectural historians.'[12] In over a century, then, little had changed, and medieval carpentry was still reckoned unfit for serious academic study.[13]

The ubiquity and mundanity of their work explained the medieval indifference to the carpenter and carpentry. A mitigating factor may be adduced here to explain why the work of the carpenter was ignored by later critics: the nature of the medieval carpenter's raw material. The stuff of the carpenter's craft, 'green' unseasoned oak, is unstable.[14] With time, green timber loses its moisture, and as it does so it shrinks and cracks. Thus, even after a few years, no matter how precise the initial cutting and how tight the joints, in structures carpentered from green oak sizeable gaps inevitably appear. Timbers twist and gape with fissures; once sharp arrises split and flake. Thus, compared with the mason's work in stable stone, still often as crisp and precise as the day it was laid, to the undiscerning eye the carpenters now warped and fatiscent work looks crude (Fig. 1.4). The observer requires insight to see beyond the now rude appearance of old carpentry and appreciate the intellect and creativity behind the design. For critics devoid of such insight, condescension ensues. In her major mid twentieth-century work

first English work of any academic intent was published in 1914: F. E Howard's 'On the Construction of Medieval Roofs', *Archaeological Journal,* Vol. 71.

[12] (Harmondsworth: Penguin, 2nd ed., 1965), 185.

[13] In Peter Brieger's standard work in the OUP series *English Art 1216-1307* (1957), the words 'carpenter', 'timber' or 'woodwork' do not appear in the index. In the subsequent volume on the fourteenth and early fifteenth century, *English Art 1307-1461* (1949) – a golden age of technical innovation and aesthetic accomplishment in carpentry - Dame Joan Evans's also gives the carpenter short shrift. To timber roofs in general, built by men who William Harrison (writing albeit 100 years later than our period) described as having 'excellency of device', producing 'curious and excellent' works, men 'worthily preferred before those of like science among all other nations', (Harrison, 276, 277, 199), Evans concedes just one sentence (p. 211, 212). To the roof of Westminster Hall she devotes six lines (p. 136).

[14] Julian Munby, 'Wood', in John Blair & Nigel Ramsey (eds.), *English Medieval Industries* (London: Hambledon, 1991), 382. The modern dating process of dendrochronology is contingent on the fact that medieval carpenters used green oak. Elm and chestnut were occasionally used for structural purposes, but the overwhelming majority of timber buildings were in oak. Traditional English 'framers' still use green oak today.

on English art in the OUP series, Dame Joan Evans commented thus: 'Timber-framed houses are peculiarly subject to decay, to destruction by fire, and to successive modifications; few kinds of architecture – *if indeed the word can be applied to them* – are harder to use as historical evidence' (italics mine).[15]

And yet, evidently (and likely to the chagrin of the intellectually aspirational mason), a medieval Clerk of Works understood the value of the carpenter much more than contemporary rival craftsmen and later scholars, and it was an insight expressed in pecuniary manner.[16] The carpenter and mason of equivalent proficiency were usually paid the same; and, as the mid fourteenth-century accounts for the royal palace at Woodstock demonstrate, the carpenter was sometimes paid substantially more (Table 1.1 below).

Table 1.1.

	1346	1351	1354	1357	1365	1380
MASON	2*d*	2½*d*	3*d*	3*d*	5 - 3*d*	6*d* - 3½*d*
CARPENTER	3*d*	3½*d*	4*d*	4*d*	5*d* - 4*d*	5*d* / 4*d*
TILER	2*d*	2½*d*	3*d*	3*d*	4*d*	6*d* - 3*d*
PLUMBER	4*d*	6*d* / 4*d*	6*d*	n/a	5*d*	6*d* - 4*d*

From Salzman, p.74

Other contemporary accounts further show the carpenter ascendant in the stipendiary hierarchy.[17] The accounts for the rebuilding of Exeter Cathedral at the turn of the thirteenth century are particularly illuminating.[18] The going weekly rate for a carpenter at Exeter from 1279-1324 was from around 1*s* 8*d* to 2*s* 3*d*, with most wages being around

[15] Evans, 202.

[16] For a précis of the role of the Clerk of Works in a medieval building project see Virginia Davis's comments on William Wykeham, *William Wykeham, a Life* (London: Hambledon Continuum, 2007), 21-22.

[17] Carpenters paid more than masons recorded in Salzman: 1257 for works at Winchester, 69; 1327 at York; 1348 at Westminster, 71; 1400 at Ripon, 77. See also John Harvey, 'The Mediaeval Carpenter and his Work as an Architect', *RIBA Journal*, 45 (1937–8), p. 736.

[18] Audrey M. Erskine, (ed. & trans.), *The Accounts of the Fabric of Exeter Cathedral, 1279-1353*, Pt. I, 1279-1396 (Devon and Cornwall Record Society, 1981), *passim.*

2*s* 1*d* – 2*s* 2*d*. 'Master Walter the Carpenter' was regularly paid that sum in the long days of the spring, summer and autumn 'terms', his wages peaking at 2*s* 3*d* in the early spring of 1300.[19] To put that sum into context, masons were paid a similar amount, usually from around 1*s* 6½*d* – 2*s* 2*d*, and ordinary labourers were paid around 9*d* – 11*d* per week, sometimes much less. Up to around 1317, 2*s* 3*d* seemed to have been the wages ceiling, with virtually no named craftsman, whatever his trade – be it mason, carpenter, plumber - paid more. Of regular workers only the Master of Works, for example Roger the Mason (*fl.* 1296-1310), was better remunerated. Roger's wages amounted to 30*s* per term, a regular income of approximately 2*s* 3½*d* per week, in addition to the perquisite of a house.[20] Nonetheless, despite such an egalitarian wage structure, examples can be found in the accounts of carpenters being paid more than masons. In 1316, an unnamed carpenter 'making galleries' was paid the unusually high wage of 2*s* 6*d* for the week, while a mason 'refitting the altar of St Stephen in the choir', was paid 5*d* for day and half.[21] In 1324, for a week's work three carpenters were paid 5*s*; two masons 3*s*; while eleven masons were being paid a total of only 12*s*.[22] Also at work in 1324, 'Sewane Adam' must have been an exceptional carpenter, as he was both named and paid the exceptional sum of 2*s* 9 ½*d*, during a week when two masons were paid a total of 2*s* 6*d*.[23]

With the caveat that below a relatively constant stipendiary ceiling, craftsmen of whichever profession were paid a variety of wages evidently accordant with their proficiency, the salient points to draw from the Exeter accounts are these: carpenters were often paid the same, sometimes more, than their masonic counterparts, and carpenters were always found among the top wage earners. To demonstrate the latter

[19] Erskine, 176-7. In theory, the terms were of 13 weeks: Michaelmas, Christmas, Easter, and Midsummer, but as Easter was a moveable feast, the length of the terms was adjusted accordingly

[20] The disparity between the pay Master Roger, the 'warden' of the works, and that of the higher craftsmen seems surprisingly slight, but Roger's work was regular and relatively secure compared to other craftsmen who were hired and fired as needed. See also his entry in *EMA.*

[21] Erskine, 76.

[22] Erskine, 153. The wages are relatively low here, so this was perhaps low-grade work. The accounts mention 'houses in Kalendarhay.'

[23] Erskine, 153. These examples are difficult to locate however. The difficulty with the Exeter accounts is that on occasions when craftsmen are named, often their profession is not given. So, to give a spurious example, 'John Jankyns' may be listed as earning more than 'James Joye', but their respective trade is not listed.

point, for the Michaelmas to midsummer period of 1299-1300, excepting Master Roger, 2*s* 3*d* is the highest wage paid, and only three men earn it: Richard de la Streme, William de Meriet and Walter the Carpenter.[24] De Meriet was also a carpenter; only de la Streme was a mason. Thus, of three top earners during the early stages of the rebuilding of Exeter Cathedral, two were carpenters.[25]

We cannot know to what extent, if any, these woodworkers were involved in any planning and design of the new works, but their high wages clearly shows that they were pivotal figures in the medieval construction process, and not only in typical carpenters' work such as the construction of roofs. As will be seen later, the whole character of a medieval great church, right from the early stages of construction, depended on the carpenter. The medieval bureaucrat, then, clearly understood a fact that has been lost. Without the imagination, invention and craft of the carpenter, the soaring architecture, so acclaimed by nineteenth-century antiquarians and admired by awe-struck visitors today, would not exist.

The Versatility of the Carpenter

Perhaps one factor which made the carpenter so valuable was that he was a versatile craftsman, able to adapt his skills to a variety of construction challenges. Carpenters built bridges and pile-drivers, siege engines and temporary fortifications. They designed and built ingenious lifting devices – cranes and hoists – essential for the construction of ever-taller buildings in the later medieval period.[26] Carpenters constructed shuttering for rubble walls, and scaffolding to raise those walls; they fashioned the templates from

---

[24] Exception also is made for the highly anomalous sum paid to Golofre the quarryman of 7s per week, which must have included other expenses such as transport costs or payment to employees.
[25] Erskine, 175-177.
[26] Gervase of Canterbury records the fabrication of lifting devices and 'machines' for the reconstruction of the cathedral, Teresa G. Frisch, *Gothic Art, 1140 - 1450: Sources and Documents* (Toronto / London: University of Toronto Press, 1987), 17, 19. A number of folios in Villard de Honnecourt's portfolio (*c*. 1220-40) show wooden machines used in the construction process, Bibliothèque Nationale de France (MS Fr. 19093); Hans R. Hahnloser, ed., *Villard de Honnecourt: Kritische Gesamtausgabe des Bauhüttenbuches …* (Graz: Akademische Druck- u. Verlagsanstalt, 1972). See also Jean Gimpel, *The Cathedral Builders* (London: Pimlico, 1993), 96; Eric Fernie, *The Architecture of Norman England* (Oxford: OUP, 2000), 297.

which the mason cut his stone, and made the wheel-barrows for him to ferry that stone about site. Adjacent to the site they constructed elaborate lodges to permit the masons to work, eat and sleep sheltered from the elements.[27] Versatility was required even of the humble country carpenter:

> Of erthely man hadde he no dowte,
> To werke hows [hoes], harowe, nor plowgh,
> Or other werkes, what so they were,
> Thous wrought he hem farre and nere,
> And dyd tham wele I-nough.
>
> By þat tyme þe lord of the towne
> Hadde ordeynyd tymbyr redy bowne,
> an halle to make of tre.
> After the wryght the lord lett sende
>
> *The Wryght's Chaste Wife* (*c.* 1462)[28]

In this world of plastics and mass-produced metals, it is difficult for the modern observer to appreciate that most utilitarian items in the medieval period, from mill-wheels to mole-traps, bridges to buckets, were made of wood.[29]

Operating for a different stratum of clientele, the career of Richard II's and Henry IV's carpenter, Hugh Herland (*c.* 1330-1411), confirms this versatility.[30] When we first encounter Hugh in the records he is already thirty years old and working in a supervisory capacity with his father, William, on construction works for Edward III at the Royal Palace at Westminster and the Tower. In 1367, it is likely he was responsible for the design and execution of the wooden tester over the tomb of Queen Phillipa of Hainault (wife of Edward III) in Westminster Abbey. The next year finds him in Kent, in the role of military engineer, working on Edward's revolutionary new castle at Queenborough (destroyed) on the Isle of Sheppey, and on repair works at Rochester

[27] Masons' lodges were so well constructed and spacious that upon completion of masonic work they were often sold on as homes, Salzman, 39-40; also, Fernie, 297; Gimpel 115; *EMA*, 142.
[28] A fifteenth-century poem by Adam of Cobsam but of uncertain origin, lines 13-18, 104-7. *The Project Gutenberg EBook of The Wright's Chaste Wife,* <http://www.gutenberg.org/> accessed 6/12/2012.
[29] A practice which continued well into the nineteenth century, see Walter Rose, *The Village Carpenter* (Hertford: Stobart Davies, 2001), *passim*.
[30] The following is based on the relevant entry in Harvey's *EMA*.

Castle. During this period he was paid 8*d.* a day for making 'springalds', catapults for shooting giant arrows. In 1375 he was engaged in what one may think of as run-of-the-mill carpenters' work - building a roof - that of the Abbott's Hall at Westminster Abbey. Two years later he designed 'one of the finest compositions in gothic art': the tester of the tomb of Edward III (See figs. 21-23). A vaulted structure adorned with filigreed tracery, John Harvey considered it, 'the very highest point in the design of decorative woodwork.'[31] Later, in the timber vaults of the Collegiate Church at Arundel (c. 1380-90, Fig. 1.24), and Winchester College Chapel (1387-94, Fig. 1.25) Herland developed these delicate forms and adapted them to an architectural scale. In 1397 Herland may also have designed the splendidly ornate waggon roof over the Chapter House of Canterbury Cathedral (Fig. 1.33).[32] In 1398 he was appointed (among others) to supervise the construction of a new harbour at Great Yarmouth. Also in the final decade of the fourteenth century, Herland completed his masterpiece, the culmination of his engineering nous and aesthetic sensibility: the monumental and technically audacious hammer-beam roof of Westminster Hall.

A more obscure instance of such versatility is that of a carpenter working during the rebuilding of Exeter Cathedral in the early decades of the fourteenth century: Robert de Galmeton (*fl.* 1312-26). The years 1313-16 find Robert repeatedly being paid for making centerings (*cinternas*), bulky, temporary structures fabricated to expedite the construction of masonry arches. In 1317 Robert was paid £4.00 for making that oft-cited paragon of the carpenters' art, Exeter's highly ornate and technically ambitious Bishop's throne (Fig. 1.5).[33]

The above examples demonstrate a versatile craftsman. Engineering was an integral part of that versatility, and it is to this facet of his worth I now turn.

---

[31] Harvey, *EMA*, 138. F. E. Howard and F. H. Crossley concur with Harvey, *Early Church Woodwork*, (London, Batsford, 2nd ed., 1927), 352, 354-6.

[32] John Harvey, *The Perpendicular Style 1330-1485* (London: Batsford, 1978), 132.

[33] Erskine, 73- 75, 85. Howard & Crossley, 191-5.

THE CARPENTER AS ENGINEER: CENTERING AND SCAFFOLDING

'*A machine is a combination of timbers fastened together.*'

Vitruvius, Bk. X, Ch. I: i.

Mention has been made of bridges, siege engines, pile-drivers (Fig. 1.6) and cranes, and in discussing the worth of the carpenter and his centrality to all medieval building, it is important to understand that the carpenter was the engineer of his day. The advanced state of carpentered engineering by the end of the Middle Ages is observed in Pieter Bruegel's paintings of *The Tower of Babel* of the 1560s (Fig. 1.7). Various forms of lifting machinery can be noted, from simple jibs and sheer-legs to sophisticated vertical twin-capstan windlasses. Shelters for the craftsmen are also in evidence. Easy to overlook in Bruegel's work are further carpentered structures, without which buildings of any height or sophistication were impossible: scaffolding and formwork.

'A well-made scaffolding is a feature of the builders art which engages his best intelligence … for the real skill of the builder can be judged from the manner in which he places his scaffold.'[34] Viollet le Duc's assessment of this neglected aspect of carpentry is astute. Further, the skeletal structures of the Gothic builder, which offered little scope for conventional putlog attachment, posed new challenges on the 'best intelligence' of the carpenter.[35] It is obvious that a poorly constructed scaffold could have fatal consequences for the workman, but it also had economic consequences for the patron. The worker warily watching where he places his next step is a slow worker. A well-constructed and positioned scaffold leads to an economy of progression and thus efficiency of work. But while the main function of a scaffold was to provide functional,

[34] Eugène Viollet-le-Duc, 'Échafaud', *Dictionnaire Raisonné de l'Architecture Française du XIe au XVIe Siècle,* Vol. V (Paris: Bance, 1861); phrase translated in John Fitchen, *The Construction of Gothic Cathedrals* (Chicago & London: University of Chicago Press, 1961), 15.
[35] Fitchen, 19.

mundane working platforms, in a few cases a scaffold became its own autonomous display of consummate carpentry.

Reaching a total height of 404ft (123.14m), the spire of Salisbury Cathedral is the tallest in England by some 100ft (30.5m). Of 'exquisite grace … the supreme among spires', it was the first in England to be built entirely of stone.[36] Its construction was permitted only by means of scaffolding erected by carpenters, and, inside the spire, a scaffold survives (Figs. 1.8 & 1.9).[37] Originally assumed to have been constructed for the traditional purpose of providing working platforms for the masons, following tree-ring analysis, debate has arisen concerning the intended purpose of this structure. Dendrochronology has dated the scaffold to 1344–1376.[38] Yet the masonry of the spire has an uncertain construction date of anywhere between 1300 and 1360, with most authorities settling on a completion dates between 1300 and the early 1330s.[39] Clearly, therefore, a chronological discrepancy exists which casts doubt on assumptions that the scaffold was erected to expedite the construction of the spire. The heaviness of the structure - its own self-weight is estimated at forty-five tons, its complex design, and its technically advanced framing, also indicate that the carpenters had a more sophisticated

---

[36] Alec Clifton-Taylor, *The Cathedrals of England* (London: Thames & Hudson, revised ed., 1986), 179.

[37] The most detailed recent analysis of the structure of the spire and scaffold is Tim Tatton-Brown's 'Building the Tower and Spire of Salisbury Cathedral', *Antiquity* 65 (1991), pp. 74-96. Tatton-Brown summarises the framing of the scaffold in 'The Archaeology of the Spire at Salisbury Cathedral', in Keen & Coke (eds.), *Medieval Art and Architecture at Salisbury Cathedral* (Tring: British Archaeological Association 1996), 59-67, which also contains the most elucidatory illustrations of the framing.

[38] *ADSDD*, 'Salisbury, The Cathedral, Tower & Spire', <archaeologydataservice.ac.uk/archives> accessed 4/12/2012.

[39] No documentary evidence which may accurately date the building of the spire has been uncovered. Stanford Lehmberg says accurate dating is guesswork and suggests 1300-30 (p. 31); Robert A. Scott (pp. 25-6) says the spire was begun *c*.1300; Clifton-Taylor (p. 179) says it was probably constructed in the 1330s; Christopher Wilson (p. 175): 'probably completed by 1328'; *AC* (p. 412): 1300-40. Stanford Lehmberg, *English Cathedrals: a History* (London: Hambledon, 2005); Robert A. Scott, *The Gothic Enterprise* (Berkeley and London: University of California Press, 2003); Christopher Wilson, *The Gothic Cathedral* (London, Thames & Hudson, 1990). The ADSDD, perhaps the most recent source, states 'the first quarter of the fourteenth century'; Tatton-Brown in his discussion of the dating difficulties (1991, pp.94-96) concludes that the spire was 'built rapidly in the years surrounding 1300', p. 96. By 1996, and with the results of the dendro-analysis pending, Tatton-Brown was still advocating a date in 'the earliest years of the 14th century', p. 59. John Harvey in *EMA* says the spire was begun in the 1320s but not completed until well into the second half of the C14. Following tree-ring analysis, Harvey's dates would fit well with the previously held assumption that the scaffold was intended for the original construction of the tower, but unfortunately Harvey supplies no evidence for his assertion.

intent.[40] For this is no mere assemblage of alder poles, lashed together to provide temporary staging. The oaken scaffold constitutes one of the supreme achievements of fourteenth-century carpentry - a bewildering array of posts, braces and joists, all framed in ingenious manner. The carpenters used pegged mortice and tenon joints extensively, and included highly sophisticated scarfing techniques (Cecil Hewett believed them innovatory) - joints which demanded a high degree of three-dimensional spatial imagination to conceive, and consummate craftsmanship to cut (Fig. 1.10).[41] A mast-like central post is the principle structural feature, of necessity scarfed to obtain adequate length. From its higher levels a series of inclined struts radiate, similar to the spokes of an opened umbrella. If the scaffold was designed merely for the support of construction staging, then it is certainly over-engineered.

It now appears, however, that this extraordinary structure had an extraordinary purpose, transcending that of mere access scaffolding. Current archaeological opinion is that the scaffold's function was threefold: 'to repair damage sustained by the top of the spire in a great storm in AD 1362, to provide some tensile restraint for the capstone, and to give permanent internal access to the top of the spire.'[42] It is the second of those functions, to provide tensile restraint to the capstone, which is the most remarkable.

When the carpenter Francis Price (*c.*1704-1753) surveyed the scaffold during his tenure as Clerk of Works at Salisbury he felt moved to note 'the architect's particular and curious invention, for adding artificial strength' to the spire.[43] Price continued, 'this timber frame … was always meant to hang up to the capstone of the spire, and by that means prevent its top from being injured in storms, and so add a mutual strength to the shell of stone.' For the topmost portion of the scaffold the medieval carpenters contrived an iron assemblage, a contrivance of such importance that Price exhorted 'it is … worthy of the strictest observation, to keep all these connections in good repair.'[44] The top of

[40] *EHC*, 142; the structure is discussed pp. 141-5.
[41] *EHC*, 265.
[42] *ADSDD*, <archaeologydataservice.ac.uk/archives> accessed 4/12/2012.
[43] Francis Price, *A Series of Particular and Useful Observations, Made with Great Diligence and Care, upon that Admirable Structure, the Cathedral Church of Salisbury* (London: Printed by C. and J. Ackers ..., 1753), 16.
[44] Price, 17. The ironwork can be discerned in Hewett's drawing, fig. 1.8.

this ironwork the carpenters connected to the masonry capstone; its lower end they fixed to the central mast of the scaffold. At the base of the spire, where the inclined shoulders commence, the scaffold is stabilised only by two timbers of relatively slender section, timbers that were clearly not meant by the medieval carpenters to support the whole structure. Indeed, this is the only point where the scaffold originally made direct contact with the masonry. Thus, remarkably, the carpenters designed the scaffold principally as a tensile structure. It was meant to hang, chandelier-like, from the capstone.[45] Further, designed in this way, the scaffold functioned more than simply as a 'restraint for the capstone.' Its weight was transferred, via the capstone, as a compressive force down the thin shell of the stonework. Thus, the 'exquisite grace' of the mason's spire is only maintained by an ingenious contraption fabricated by the carpenter.

Christopher Wren was evidently so impressed with this example of medieval engineering that he copied it. Wren had surveyed Salisbury Cathedral and its spire in 1668-9, and when, some years later, he was commissioned to rebuild the top of the spire of Chichester Cathedral, he 'fixed therein a pendulum stage to counteract the effects of the south and south-westerly gales of wind which … had forced it from its perpendicularity … The effect in a storm is surprising and satisfactory.'[46]

Those who have studied the Salisbury scaffold eulogise. Hewett called the feat of timber engineering, 'one of the most remarkable works of carpentry known.'[47] For Tim Tatton-Brown, 'the masonry, timber [and] iron of the 180ft spire … form an extraordinarily integrated whole, which for any age would be considered a masterpiece of architectural design and civil engineering.' And, in addition to being 'among the most important examples of medieval technology', Tatton-Brown concluded that both the spire and scaffold have aesthetic value, forming, 'some of the most beautiful parts of the cathedral.'[48] The men who carpentered this extraordinary structure were evidently

---

[45]Tatton-Brown (1991) 90-91. 'Chandelier' is Tatton-Brown's analogy, 92.

[46] Tatton Brown (1991), 92. For Wrens 'pendulum': James Elmes, *Memoirs of the Life and Works of Sir Christopher Wren* … (London: Priestley and Weale, 1823), 520 and illustration p. 486; also Bell's Cathedral Guide, *Salisbury* (London: George Bell & Sons, 1901), p. 42.

[47] *EHC*, 143-45.

[48] Tatton-Brown (1991), p. 94; (1996), pp. 65-66.

proud of their achievement, as, although a structure that would remain unseen to most, they took the trouble to adorn the major timbers with stopped chamfers.

CENTERING

Returning to Bruegel's fictive tower (Fig. 1.7), also clearly visible are further examples of carpentered engineering: the falsework and formwork used to construct centering for the many vaults and arches under construction. Centering is the temporary structure used to support an arch during its construction. Once the arch is complete and self-sustaining, the centering can be 'struck', or removed. To the left of the two windlasses in the picture, on the second tier, can be seen fan-like structures supported by a single central pole. These are examples of centering. Just above, and to the left are heavier and more complex structures designed to carry a heavier load. Further examples of more complex centering are found in another version of *Babel* coeval with this work, *The 'Little' Tower of Babel* (*c.* 1565) (Fig. 1.11).[49]

The formwork depicted in Bruegel's paintings is designed for the construction of tunnel vaults – relatively simple structures constructed in a single, continuous length unbroken by lateral divisions (Fig. 1.12). During the Gothic age, as is well known, the pointed rib vault became the dominant form. For the carpenter, with their intersecting ribs and multiple planes, this was a different and more challenging proposition. With the eventual inclusion and multiplication of tierceron and lierne ribs, vaults became highly complex, demanding a corresponding complexity from the carpenter's centering.

The ephemeral, mundane, yet complex nature of such structures appear to have defeated modern analysts. Although all the major stone edifices of the Middle Ages depended on centering for their construction, little is written about these structures and the subject is still arcane.[50] The only extensive study is John Fitchen's important, if inevitably conjectural, *The Construction of Gothic Cathedrals* (1961). Fitchen comments that 'Centering was certainly the most demanding erectional problem encountered by the medieval builders … the design and technique of placing centerings became a major preoccupation of the architects, exacting from them the utmost in resourcefulness [and]

[49] Museum Boijmans-van Beuningen, Rotterdam.
[50] Fitchen, 99.

ingenuity.'[51] Bruegel's painting and a perusal of Fitchen's illustrations of possible centering solutions for medieval vaults are testament to that resourcefulness (Fig. 1.13). Furthermore, although made of roughly scabbled timber, the cost and rarity of iron and the absence of plywood meant that centering structures were not merely nailed together using plywood or steel gussets as might be the practice today.[52] 'Proper' framing - some form of pegged jointing - would be required, for the mason to then position his butt-jointed voussoirs.

Clearly, to prevent catastrophe, the centerings would need to be as strong and stable as the finished structures they were supporting. But further, it was crucial that the centering be rigid enough to prevent any degree of deformation while the voussoirs were being laid.[53] An arch ideally should be a smooth curve; any kinks can create hinge points which lead to instability and possible structural failure.[54] During the actual construction process, however, a smooth curve is not easy to maintain. In the early stages of laying, the voussoirs tend to depress the haunch and raise the crown of the centering. As the arch is completed, the reverse is true; the voussoirs act to depress the crown and force the haunches outwards. In order to resist these varying forces, rather than the use of massive timbers, Ellis recommended 'the judicious arrangement of braces' in a 'scientifically arranged frame', and his designs for centerings resemble the framing of a king-post truss.[55] These prosaic and temporary structures thus become sophisticated vignettes of carpentry in their own right.

---

[51] Fitchen, 29. Writing in 1736, the architectural author Batty Langley commented regarding centering, 'to do well, is a curious piece of workmanship', *Ancient Masonry, Both in the Theory and Practice* ... (London: printed for, and sold by the author; J. Milan; and J. Huggonson, 1736), Vol. I, p. 348. Mention has already been made of the work of Robert de Galmeton at Exeter. A further documented example of a C15 carpenter making centerings can be found in Francis Woodman, 'Hadley, Norfolk, and the Rebuilding of its Chancel', in Buckton & Heslop (eds), *Studies in Medieval Art and Architecture Presented to Peter Lasko* (Stroud: Alan Sutton in association with the Trustees of the British Museum, 1994), 204.

[52] Nails were expensive and used sparingly in medieval carpentry, see Munby, 383.

[53] George Ellis, *Modern Practical Carpentry* (London: Batsford, 3rd ed. revised, 1927), 158.

[54] Fitchen, 14.

[55] Ellis, 157-9. Thomas Tredgold, writing on the construction of simple arches in *Elementary Principles of Carpentry* (1871ed.), devotes 6 pages, 200-205, of text and calculations to the increasing pressures of voussoirs upon centering as each one is laid.

Furthermore, the centering had to be set perfectly level. This the carpenter achieved by a system of folding wedges capable of fine adjustment placed under the main structure (Fig. 1.14). The enlightened carpenter would also know that his centering would settle under load, and may have taken steps to accommodate this, for example setting his formwork fractionally higher than the final position of the rib, or by the use of individual wedges that could be incrementally adjusted after each voussoir was laid (see Fig. 1.20).[56] Once the rib was complete, the centering then had to be struck, removed intact, or at least in sections, for it to be re-used in a further bay. Wholesale dismantling was inefficient. The carpenter eventually devised a variety of ingenious methods to strike the centering, but, for the medieval carpenter, the simplicity of the folding wedge would likely have been the preferred device (see Fig. 1.14).

Figures 1.15 & 1.16 indicate the complexity these structures had to attain in order to sustain complex vaults. The formwork for the ribs, must integrate with that for the webbing, set on a higher plane.[57] Compound angles, always a headache for the carpenter, abound. Further 'cunnyng' carpentry was demanded in the centering where the ribs intersected at the crown of the vault – no simple orthogonals here. Often, the boss hung lower than the ribs – a third plane for the carpenter to accommodate. Finally, it must be remembered that not all vaulting is orthogonal in plan. The challenges involved in designing the centering for a trapezoidal bay, for example in the curve of an ambulatory, were immense (Fig. 1.18).

Peter Nicholson (1765-1844) was one of the few early writers on carpentry to tackle the subject of centering and 'cradling of groins.'[58] As well as apsidal vaults, among other sophisticated structures, Nicholson discusses 'under pitch' groins, in which the intersecting lateral vaults are lower, and 'ascending groins', for instance, those which

---

[56] Roland Mainstone, *Developments in Structural Form* (Harmondsworth: Penguin, 1975), 73, 74.

[57] I must depart from Fitchen's illustration here as it seems over engineered. To support the webbing in English cathedrals carpenters merely inserted boards between the ribs which they then removed when the webbing was stable. Timbers still *in situ* can be found in the east gallery of the choir of Chichester Cathedral (Fig. 17), and at Lincoln Cathedral. For Lincoln see Wilson, 27. I am grateful to Clerk of Works Mr Ralph Tyreman for allowing me to view the Chichester example.

[58] Peter Nicholson, *The Carpenter's New Guide: Being a Complete Book of Lines for Carpentry and Joinery* ... (London: printed for J. Taylor, 6th ed., 1814), 22-32.

follow a staircase. In ten pages of drawings baffling to the layman - and only slightly more illuminating text - Nicholson explains how to lay out such complex carpentry. A high degree of geometrical skill is required to devise such plans, and much study and practice would be required for the carpenter to become proficient in both of design and execution. But proficient he became.

The construction of centering demanded that the craftsman carpenter bulky timbers into a state of high precision, and position them meticulously at a dizzying height. The subsequent stability of the vault depended on such precision. The mason then merely placed his eternal voussoirs, precisely cut, possibly to a pattern made by the carpenter, on the carpenter's elaborate but ephemeral structure (Figs 1.19-21). Technical advances in vaulting must have depended to a large extent on the creativity of the carpenter, since the initial form was provided by him.[59] The development of Gothic vaulting, recognised as one of the great artistic achievements of the late medieval period, followed the form the carpenter gave it.[60]

An obvious objection exists to counter the above argument, and it proceeds as follows: these structures were masonry enterprises, and in original documents it is the mason that is frequently referred to as the 'master'. The mason, therefore, was the architect, the creative force on site. The carpenters were banausic, without creative input, merely 'following orders' as they executed the mason's designs and instructions. Some headway has already been made in rejoining that objection by comparing carpenters' wages. Further progress may be made by consulting a further contemporary account.

William of Sens (d. 1180) never recovered from injuries sustained after falling from the scaffolding while working on the choir of Canterbury Cathedral in 1178. He had been preparing 'the machines [possibly centering]… for vaulting the great vault'. Nowhere in Gervase of Canterbury's contemporary account of the works on the choir is William described as 'a mason.' Rather, he is referred to as 'the master.' A man of 'lively genius', he was retained to supervise the new works because he was a craftsman 'most

---

[59] Fernie, 297.
[60] Fitchen, 29, 30.

skilful both in wood and stone.'[61] The syntax of Gervase's sentence may be accidental in giving precedence to William's skill as a carpenter. Nonetheless, the master builder of one of the first Gothic enterprises in England was no mean woodworker. 'He constructed ingenious machines for the loading and unloading of ships'; 'he delivered moulds for shaping of the stones to the sculptors … and diligently prepared other things of the same kind.' These preparatory works for the mason are typical carpenters' work. Gervase's account, then, testifies that the master builder of one of the watershed structures of medieval architecture, in addition to being conversant with the arts of masonry, was a carpenter. For succeeding masters, a knowledge of carpentry, or recourse to a master carpenter, would be imperative.

Up to now, by means of some lesser known aspects of his work, I have been looking at the carpenter from a technical viewpoint, as a builder and engineer. But the carpenter, in his best work, also displayed the creativity of an artist. It is the carpenter's aesthetic contribution to medieval architecture that now comes under consideration.

[61] Gervase of Canterbury (1141-1210), 'On the Burning and Repair of the Church of Canterbury', in Frisch (ed.), 17.

The Carpenter As Artist

In addition to purely functional engineering accomplishments, carpenters were capable of work of the utmost refinement and aesthetic sensibility. In the earlier discussion of the versatility of the carpenter, I mentioned Hugh Herland's tester for the tomb of Edward III (1377) and his ecclesiastical oak vaults at Arundel and Winchester. These works demonstrate a mastery of design and proportion. The tester is a remarkable structure (Fig. 1.22-24). Internally a filigreed vaulted structure, of a multiplicity of ribs akin to fan vaulting, externally the vault is flanked by double pendant arcades composed of cinquefoil ogee arches alternating with pinnacles, all studded with crockets. It is microcosmic architecture of a delicacy impossible in masonry. Later, in the vaults at Arundel (*c.* 1380-90) (Fig. 1.25), and Winchester College (1387-94) (Fig. 1.26), Herland developed these dainty forms and adapted them to a grander scale, creating structures which explored new concepts of vaulting. It is to such timber vaults that we now turn our attention in order to explore the artistic merit of the carpenter.

Timber Vaults

Although, as we shall see, cogent evidence of the carpenter's worth as an artist, timber vaults have been lambasted by generations of critics. Judged deceitful in their expression of construction, for A. W. N. Pugin and John Ruskin they were a sign, no less, of 'moral delinquency.'[62] In words adumbrative of twentieth-century Modernist manifestoes,

---

[62] Ruskin: 'a direct falsity of assertion respecting the nature of the material, or the quantity of labour …, is in the full sense of the word, wrong; it is as truly deserving if reprobation as any other moral delinquency … it has been a sign … of a singular debasement of the arts', 'The Lamp of Truth', *The Seven Lamps of Architecture* (New York: Dover, 1989; first pub. 1849), p. 34; see page 36 for Ruskin's comments specifically on wooden vaulting. Pugin damned them thus: 'Wooden groining is decidedly bad, because it is employing a material in the place of and after the manner of stone, which requires an entirely different mode of construction.' *The True Principles of Pointed or Christian Architecture* (London: JohnWeale, 1841), 41. For Pugin's acolytes, the architects and writers J. Arthur and Raphael Brandon (discussed later), wooden vaulting was an act both of fraud and madness: 'deception, which of course no well-regulated mind would condescend to practise.' *The Open Timber Roofs of the Middle Ages* (London: James Rimmell & Son, New Ed., 1873, [first pub. 1849]), 24. Contempt for timber vaults prevailed well into the twentieth century. Of the timber vault in the nave of Warmington Church, Northamptonshire, possibly the earliest extant example, Nikolaus Pevsner, the doyen of

these writers condemned earlier carpenters for the absence of a moral philosophy of 'honest expression of materials.' Yet such sanctimony would never have occurred to medieval artisans who often delighted in illusion and hoodwinking the observer.[63] The earliest known reference to English timber vaults is in the instructions issued by Henry III concerning the completion of his new Chapel of St Edward at Windsor in 1243: 'to cause work to go on … and to have a high wooden roof made after the manner of the new work at Lichfield, *so that it may appear to be stonework*' [italics mine].[64] It is unclear whether Henry preferred a timber vault for mischievous, visual, or economic reasons.

The twentieth–century scholar and author Alec Clifton-Taylor was also sniffy about timber vaults. The Chapter House of York Minster (1275-90) is, according to Clifton-Taylor 'one of the finest parts of the Minster', but 'the pretty star shaped roof … is only wood imitating stone. More memorable are the windows …'[65] (Fig. 1.27). Admittedly, the Chapter House vault at York is a work of visual deceit, and not only in 'falsity of assertion respecting the nature of the material.'[66] Further chicanery is encountered in the assertion of structure. The ribs support nothing, but are suspended from the surmounting spire carpentry. Yet consider Fig. 1.27, and how the complex design of lierne, tiercerons and roundel coalesce to create a sunburst effect not without symbolism to the medieval mind. In this venue for diocesan politics, all truth (and error) would be revealed under the searching divine light. Then consider Hewett's expository

twentieth-century architectural critics, grumbled, 'the vault is alas of timber, an acute disappointment', Pevsner, *Northamptonshire* (Harmondsworth: Penguin, 1973).

[63] In his hall at Guildford, Henry III ordered wooden columns to be painted to resemble marble, Nicola Coldstream, *The Decorated Style: Architecture and Ornament, 1240-1360* (London: British Museum, 1994), 118. The medieval carpenter's taste for illusion is discussed later in this thesis in Chapters 6-8. Paul Frankl contended that Gothic masonry ribs were primarily aesthetic features with often little structural function: 'even though the ribs do not bear any weight, they appear to do so. Even though the webs are heavy, they appear to be light', *Gothic Architecture*, (Yale University Press, revised ed. 2000), 47. Debate continues as to the structural role, if any, of the masonry rib; see *ibid*, 305, nt. 17a; Nicola Coldstream, *Medieval Architecture* (Oxford: OUP, 2002), 55-6, 58-60. For the Gothic architect's taste for the anti-rational and the illusory, see also Wilson, 194, 208; Coldstream in *AC*, 96-97, and Coldstream (1994), 48.

[64] *Close Rolls of Henry III* 1242-47, (London: HMSO, 1916), 39, quoted in *HKW*, Vol. II, 868.

[65] Clifton-Taylor, 166.

[66] Ruskin in nt. 61 above.

drawings of the carpentry of the vault and spire (Figs 1.28 & 1.29). The conclusion is unavoidable that, irrespective of later capricious censure, wooden vaulted structures could become both consummate technical and exquisite aesthetic achievements.

From a technical perspective, all the problems of centering are present in the construction of timber rib vaults: non-orthogonal framing, a multiplicity of compound angles – but the design and framing difficulties are still greater. With no falsework to serve as temporary support as in masonry rib construction, the timber ribs have instantly to be self-sustaining arches. Also, in contrast to the temporary and purely functional nature of centering, the vault is a permanent construction, designed to be seen and have visual worth. It must, therefore, be of an appropriate, refined construction and finish.

Medieval patrons must have specified timber vaults for prosaic reasons of structure and economy. Wooden vaults were lighter, cheaper, and able to bridge wider spans than masonry vaults. Measuring almost 50ft (15.24m), the widest spans of any English medieval ecclesiastical structure are the nave and transepts of York Minster, and all were completed by timber vaults (Fig. 1.30).[67] Their inherent lightness and decreased thrust meant that the walls of the central vessel of such a great church could be built higher, and an impressive loftiness could be imparted drawing the gaze of the faithful heavenward. Most timber vaults, though, were aesthetically unremarkable. Nonetheless, as can be seen from the York Chapter House vault, carpenters were sometimes able to transcend mere mundane 'spec', and create works of significant artistic value. Further, it seems that patrons even of the very highest status sometimes favoured a timber vault for its aesthetic potential.

Edward I commissioned St Stephen's Chapel, a new family chapel for his royal palace at Westminster, in 1292 (Fig. 1.31).[68] Most scholars agree that his intention was to rival the splendour of his cousin Louis IX's personal chapel in the Royal Palace in Paris,

[67] Measured 16/04/2013 with Bosch GLM 80 Laser Rangefinder. Nave span at second bay from west at wall plate level: 49ft 9in (15.22m). Span of S. Transept, between piers (measuring height 4ft (1.22m) above floor surface): 48ft 9in (14.92m). I am indebted to Rebecca Thompson, Superintendent of Works, and Paul Greene, Building and Services Manager, for allowing me into the roof-spaces.

[68] The present building is mainly nineteenth-century. Most of the medieval structure, much altered in subsequent centuries, was destroyed by fire in 1834. Only the medieval under-chapel remains, much restored.

Sainte-Chappelle (begun 1240).[69] The construction of St Stephen's, however, got off to a faltering start, only regaining momentum in the reign of Edward III. By 1348, the masonry shell and roof were complete; it then needed to be decorated and furnished. Edward III commissioned a splendid, fantastical interior, sumptuously decorated with polychrome walls and fittings, and large stained glass windows. Profligate sums were lavished on materials - gold, azure and vermilion - to embellish the entire interior.[70] Every surface was gilded and painted. After recent victories at Crecy and Calais, this 'most splendid chapel in England' was to be a triumphal work of a king at the zenith of his reputation (Fig. 1.32).[71] And, with a structure that soared nearly a hundred feet (30.48m) about the tiled floor, Edward chose to vault the roof in wood, 'with timbers which cannot be counted owing to the number of pieces.'[72] The span was only thirty feet (9.14m), well within the compass of the mason, and at St Stephen's, as we have noted, cost was not an issue. Thus, Edward's decision demonstrates that the timber vault enjoyed a somewhat different estimation than the opprobrium of later critics.

The design of the original roof and decorative ceiling is unknown. The chapel had already been altered a number of times over the centuries when, in 1692, Christopher Wren advised that 'the upper part of the walls be taken much lower and a new roofe be laid.'[73] Any remaining medieval work in the upper reaches of the chapel was then destroyed. It is possible, however, that the vault was no masonry-mimicking confection of springing ribs and webbing infill, but a creation with its conceptual origins in carpentry. Previous scholars have assumed a vault, though wood, of conventional

---

[69] *HKW*, 510; *AC*, 337. John Harvey commented: 'The original scheme unquestionable derived from the Sainte-Chapelle of Paris', 'St. Stephen's Chapel and the Origin of the Perpendicular Style', *The Burlington Magazine for Connoisseurs,* Vol. 88, No. 521 (Aug., 1946), 195.

[70] *HKW*, 518-19.

[71] *HKW*, 514; May McKisack, *The Fourteenth Century 1307-1399* (Oxford: Clarendon Press, 1959), 134-137.

[72] Contemporary record cited in *HKW*, 517. Edward chose to adhere to an earlier plan to vault the space in timber. During the reign of Edward II in 1326, Robert de Holebech, carpenter, was framing the timbers for the vault, then dismantling them to put in store, John Harvey, *Medieval Craftsmen*, (London: Batsford, 1975), 149. Harvey in *EMA*, p. 142, says the vault was: 'prepared in or before 1328, though not erected until 1348.' Most authorities believe that St Stephen's Chapel had a timber vault: *EMA*, 142, 155; *AC*, 337; Maurice Hastings, *St. Stephen's Chapel and its Place in the Development of Perpendicular Style in England* (Cambridge: CUP, 1955), 91.

[73] *Journals of the House of Commons* Vol. X, (London: HMSO, 1547-), 605, 618, 631; *HKW*, Vol. 5, 402.

form after the manner of Sainte-Chappelle.[74] However, the structure and aesthetic intent of St Stephen's, especially internally, departs from that of Louis IX's chapel.[75] Around the time the upper chapel was destroyed by fire in 1834, St Stephen's was subject to a series of investigations, and antiquaries recorded internal walls surmounted by a cornice of elaborate cresting, a device echoing a similar cornice on the wall arcading below (Fig. 1.33).[76] Further, a clerestory probably extended up to the timber ceiling, rendering the walls of St Stephen's much higher than recorded by the antiquaries.[77] That the walls terminated horizontally above the clerestory windows and another crenelated cornice was added, answering its counterparts below, is not an untenable suggestion.[78] A conventional vault would make nonsense of such a configuration. Further, St Stephen's was designed as a vessel for the display of imagery, one array of statuary being placed on pedestals midway up the piers of the known elevation.[79] A horizontal termination to the clerestory would have allowed the piers to extend higher, and thus permit additional

---

[74] *HKW*, 523. Hastings, frontispiece.

[75] See the comments of Christopher Wilson in *AC*, 337-8,

[76] John Carter, *Plans, Elevations, Sections, and Specimens of the Architecture and Ornaments, of the Remaining Parts of St. Stephen's Chapel* (London: Society of Antiquaries, 1795-1811); J. T. Smith, *Antiquities of Westminster* (London: 1807), *Sixty-two Additional Plates to Smith's Antiquities of Westminster* London: 1807-09) ; John Topham, *An Account of the Collegiate Church of St Stephen …* (London: Simpkin, & Marshall, 1834); Edward Wedlake Brayley & John Britton, *The History of the Ancient Palace and Late Houses of Parliament at Westminster*:.. (London: John Weale, 1836).

[77] After scrutinising the drawings of Westminster by Anton van den Wyngaerde (*c*. 1550) and Wenceslaus Hollar (1647), and noting the comments of Wren in 1692, most scholars conclude that the upper chapel of St Stephen's had a clerestory, Harvey (1946), 195, 196; *HKW,* Vol. 5, 402-3; Hastings, 57, 63-4; *AC*, 337. Interestingly, however, Wren mentions no clerestory, merely referring to lowering the walls, *Commons J.,* Vol. X, 605, 618, 631; *HKW*, Vol. 5, 402. A drawing of 1720-30 shows a clerestory, but much reduced in height; British Museum, cat. no.: 1880,1113.1350. Brayley & Britton and Lethaby thought there was no clerestory. Brayley & Britton, 453; W. R. Lethaby, *Westminster Abbey and the King's Craftsmen* (London: Duckworth & Co., 1906), 191.

[78] Jean Bony: 'The upper chapel was never meant to be vaulted, its walls had to terminate horizontally and the battlemented cornice is well-known to have been one of the hallmarks of court work in the early 1290s', *The English Decorated Style: Gothic Architecture Transformed 1250-1350* (Oxford: Phaidon, 1979), 60. Bony gives further coeval examples of horizontal terminations at the wall-head. Christopher Wilson remarks of internal 'elevations obviously intended to end with emphatic horizontals immediately above the main windows', *AC*, 337.

[79] Wilson (1990) describes St Stephen's as 'architecture centred on images and deriving its character from the canopies over those images', and '[the builder] saw the inclusion of statues as necessitating the elimination of a vault as well as vault responds', 192, 196; *AC*, 338. See also the Drawings of Frederick Mackenzie, *The Architectural Antiquities of the Collegiate Chapel of St. Stephen, Westminster, the late House of Commons* (London: John Weale, 1844), especially pl. 7.

locations for canopies and their sculpted denizens, locations which would otherwise have been occupied with the shafts, ribs and springing of any conventional vault.[80] If, however, in the pursuit of form and ornament Edward's splendid chapel was not completed by a conventional vault, albeit of timber, then what kind of structure could accommodate those aesthetic objectives?

In his conjectural drawings of the upper elevations of St Stephen's (1844), Frederick Mackenzie assumed the horizontal terminations of the walls, but proposed a complex ersatz hammer-beam construction of entirely decorative function (Fig. 1.34).[81] Angel 'hammer' beams, framed into the vertical midpoint of wall posts, project into the internal space, producing, with their attendant arch braces, a trefoil, the interstices of which are filled with timber tracery. 'Hammer' posts rise to a cambered tie beam. A minor vogue did develop in the fourteenth century for inserting vista-dominating, structurally redundant carpentered trefoils (discussed in Chapter 4), an arrangement which ostensibly resembles hammer-beam framing. Examples, however, have come to light in the twentieth century, so it is unlikely Mackenzie was aware of this development. Rather, in inventing this confection, Mackenzie clearly had in mind the form, if not the carpentry, of Westminster Hall of half a century later. The wall posts of such framing, however, would have precluded the masonry niches and statuary of the upper elevations, and as St Stephen's was designed as a setting for imagery, another form of carpentry was perhaps deemed more appropriate.

A barrel vault was the obvious solution. Such a vault, springing from the wall-head above the cornice, would have left the aesthetic programme intact, and would have delivered a casket-like appearance to what was a structure akin to an architectural jewel-box.[82] A masonry barrel vault would have brought with it inherent aesthetic and structural problems. From an aesthetic perspective, masonry barrel vaults, of often unadorned appearance, are dull. Also, as a form belonging to an earlier age, such a vault

[80] Wilson refers to the 'freeing of wall surfaces by the omission of vaulting', *AC,* 338. See also Wilson (1990), 196, and *EMA*, 327, for comments on the interior design and the effect on it by any conventional vaulting.
[81] Mackenzie, pls. 5-9. For the roof of St Stephen's, *viz*. the structure which excludes the weather, Mackenzie posited tie-beam / queen-post carpentry.
[82] See Coldstream in *AC*, 93, for buildings designed to resemble reliquaries.

surmounting a state-of-the-art royal chapel would have been unacceptably passé. From a structural perspective, springing from such a position high on the wall, a masonry barrel vault would have exerted tremendous thrust along a plane ill-equipped to handle it. All the early illustrations of St Stephen's imply a lightly buttressed structure, and increasing the buttressing would have ruined any external casket-like aesthetic.

The timber counterpart of a masonry barrel vault is the waggon roof. St Stephen's Chapel was perhaps complemented by a splendid example of this technique, in the manner of the oak roofs in the Chapter House of Canterbury Cathedral (1397) and the chancel of St Mary's, Bury St Edmunds (fourteenth-century) (Figs: 1.35 & 1.36).[83] Carpentered frame and panel construction would have had no difficulty overcoming the inherent monotony of a masonry barrel vault. Frame timbers can be of differing sections, providing relief and texture; they can be elaborately moulded and terminate in a multitude of carved bosses. Panels also lend themselves to carved decoration - to say nothing of the applied paint and gilding which would accentuate such features (Fig. 1.37). Springing from both structural and aesthetic demands, then, the craftsmen at St Stephen's created a work of art, exclusively of carpentered, not masonic, conception and execution.[84]

The true nature of the vault in St Stephen's may never be known with certainty. Indeed, the Victorian artist of fig. 1.32, probably influenced by the Mackenzie drawings, also assumed some form of hammer-beam structure. The point to draw out from this discussion of St Stephen's is this: Edward III's timber vault testifies that fourteenth-

[83] A waggon roof was suggested by Lethaby, 190. The vague date for St Mary's is from *NHLE*. Interestingly, Harvey (1978) attributes the Chapter House roof at Canterbury to Hugh Herland, 132. Waggon roofs, visually, if not structurally, the timber equivalent of the masonry barrel vault, were especially popular on the near continent, the earliest examples dating from the twelfth century, Patrick Hoffsummer, *Roof Frames from the 11th to the 19th Century: Typology and Development in Northern France and in Belgium* (Turnhout, Belgium: Brepols, c.2009), 155-158. Under-researched in the UK, they seem to have been a popular roof-type in the West Country in the late C14, & C15. Almost exclusively ecclesiastical, a fine example is in the Church of St Peter and St Paul, Shepton Mallett, Somerset (*c*. 1450), containing 350 hand-carved English oak panels.

[84] Interesting in this context are the Victorian architect George Edmund Street's comments: 'There is no greater limitation to the architect who loves variety of outline, plan and effect, than the obligation always to cover his building with a stone groined roof … we may well be satisfied to put up with an occasional loss of grandeur, if it thus involves so great a gain of loveliness and interest', 86. Street's most famous work is The Royal Courts of Justice on The Strand, London.

century carpenters, in addition to feats of engineering and construction, were in demand to create works of the utmost refinement for the most exacting of clients.

The installation of the vault at St Stephen's was overseen by the King's Carpenter William Hurley (*fl.* 1319-1354), a craftsman who had demonstrable expertise in the construction of timber vaulting of the finest quality. In 1322 the central tower over the crossing of Ely Cathedral collapsed, taking much of the masonry of the four central piers with it. The *Anglia Sacra* records that, initially, the man entrusted with the care of the fabric of the cathedral, the Sacrist Alan of Walsingham 'knew not which way to turn himself or what to do for the reparation of such a ruin.'[85] It was probably Alan, however, 'with the help of God and his pious mother Mary', who eventually had the vision to see the disaster as an opportunity to open up the crossing area and create an unprecedented octagonal space.

For the mason, alas, Alan's vision meant that they were excluded from participating in the construction of the magnificent, avant-garde structure. A huge octagonal vault carrying a lantern was impossible in masonry.[86] 'Designed with great and astonishing subtlety', the multi-ribbed vault and lantern over the crossing at Ely Cathedral (1328-39) were the product of the carpenter's, William Hurley's, genius (Fig. 1.38).[87] And this work, 'cunningly framed' by 'subtle craftsmen', is no flimsy structure reeking of compromise due to the unfeasibility of a more monumental masonry counterpart. The timbers of the octagon and lantern have a self-weight estimated at 450 tons.[88] At 62ft (18.89m), the unseen timbers propping up the lantern are the longest

[85] In John Maddison, *Ely Cathedral Design and Meaning* (Ely: Ely Cathedral Publications, 2000), 62-63.
[86] Wilson, 197-8.
[87] Monk of Ely, *Anglia Sacra*, i. 643, translated in Salzman, 390. Hurley is described as the master who had 'a definite and continuous authority in the building', F. R. Chapman, *The Sacrist Rolls of Ely*, (Cambridge, 1907), Vol. I, 45. The most detailed discussions of the construction of the vaulting and lantern are in Hewett's *EHC*, 161-4 and *ECMC*, 114-122. Although his prose is not the most limpid, Hewett's drawings are elucidatory. John Fletcher briefly discusses the carpentry of the octagon in *Medieval Art and Architecture at Ely Cathedral* (London: British Archaeol. Ass., 1979), 61-65, although, while useful, the piece contains a number of errors. It should also be remembered when considering the octagon carpentry that it has undergone extensive repair and restoration.
[88] Fletcher, 63.

known in any British medieval building. Trees of adequate size to provide the timbers were scarce, documented as being 'sought far and wide, found with much difficulty, bought at a great price.'[89] The vast octagonal space of around 70ft (21.34m) in span remained the widest central void in any English building until Wren constructed the dome as St Paul's over three centuries later. In spanning such a void, Hurley accomplished a task again beyond the scope of the mason.

But again I have returned to the carpenter as engineer. The timber vault and lantern are works of art of subtle refinement and extraordinary grandeur. In 1340 during the dedication of the new octagon, they must have had an astounding effect on the attending King Edward III and Queen Philippa. We shall never know if the splendour of the vault led Edward to confirm his father's decision to vault St Stephen's in timber, but Hurley's demonstration of what the carpenter could achieve aesthetically must not have been without influence.

THE CARPENTER AS PIONEER OF FORM: FAN VAULTS AND PENDANT BOSSES.

Timber vaults achieved the pinnacle of technical and aesthetic sophistication in designs by Hugh Herland, in the aforementioned Fitzalan Chapel in the Collegiate Church at Arundel, and the chapel of Winchester College (Figs 1.25 & 1.26). Writing of Arundel in 1702, an anonymous surveyor lamented the parlous state of the structural roof, commenting 'tis a thousand pityes, [the timber vault] being the finest thing … in that kind, I ever saw.'[90] Significantly, although perhaps not fulfilling their strict criteria, it is difficult to look at these structures and not see them as experiments in the *form* of fan

---

[89] Salzman, 390; See F. W. B Charles, *The Conservation of Timber Buildings* (Shaftsbury: Donhead, 1995), 47-49, for the sizes of trees required to convert the structural timbers for the Ely octagon. Interestingly, the carpenter of the spire at York Chapter House was evidently unable to find single timbers to bridge his 58ft clear span. The two main horizontal cross-beams are each made of four timbers, framed together in a most ingenious manner (see fig. 27).

[90] 'The chancells at Arondel lye very indecently. It rains into the great chancell, and the roof thereof is, some of it, fallen downe, and the rest will quickly follow.', quoted in Rev. Mark Aloysius Tierney *The History and Antiquities of the Castle and Town of Arundel* (London: G. and W. Nicol, 1834), Vol. II, 621.

vaulting.[91] Winchester in particular, with its conoids extending laterally to central bosses and concave-sided rhomboids, is particularly reminiscent of the form. On a smaller scale, fan vaulting is certainly alluded to in the internal design of Herland's tester for Edward III (1377; Fig. 1.23).[92]

Interestingly, as Herland was constructing the tester, the first masonry fan vault was probably being completed in the east walk of the cloister of Gloucester Cathedral (Fig. 1.39).[93] The dates of the two structures are too close to establish the tester as an antecedent of the masonry fan vault, and the major vaults at Arundel and Winchester seem too late for that purpose. Nevertheless, I shall argue that Herland, with Edward's tester and the Arundel and Winchester vaults, was, at the very least, exploring the potential of a new style. Fan vaulting is not without its technical difficulties, and it took the artistic vision of a carpenter, Herland, to pioneer the way.

Fundamental to fan vaulting are the clusters of ribs, identical in profile, rising from their springing. But horizontals are equally determinate. Conventional rib clusters inevitably create conoid forms as they rise from their springing.[94] So it is the horizontals of the panelled tracery specific to fan vaulting, particularly at the point where the final horizontal, creating a rim like that of a trumpet, meets its lateral and longitudinal neighbours, that define both the aesthetic of fan vaulting, and its structural limitations.

A moment's work with a ruler and compasses determines that if the inverted trumpets extend to their full semi-circular form, fan vaulting in its purest form is only

---

[91] *EMA*, 141; Harvey (1978), 222. The most comprehensive account of the fan vault, a development peculiar to England, is W. C. Leedy, *Fan Vaulting: Study of Form, Technology and Meaning* (London: Scolar, 1980). Leedy supplies the following diagnostic characteristics: (a) conoids of regular geometric form; (b) ribs of a consistent curvature; (c) a distinct central spandrel panel; (d) ribs perpendicular to the vaulting surface; (e) applied surface patterning. Helpful also is Leedy's phrase: 'the most important characteristic of fan vaulting is that it is a double curved structure with anti-clastic curves'; in other words: concave vertically and convex horizontally, pp. 1-3, 22.

[92] *EMA*, 141.

[93] Scholars have not determined a precise date for the cloister fan vault. Wilson (1990) states that the vault was begun 1351-64, pp. 208, 210; previously John Harvey (1978) gave a completion date for the east walk of the cloister, the earliest part, of *c*. 1377, pp. 90, 92; Clifton-Taylor stated the vault was completed by 1412, p. 226; as does Leedy, who states that the construction of the whole vault belongs to 1381-1412, which would make Herland's tester the earlier structure, p. 7, also pp. 166-8.

[94] See Wilson, 208, for comments on conoid forms in the vaulting of the choir of Gloucester Cathedral (comp. *c*. 1360), which is not recognised as a fan vault.

suited to bays square in plan. Most large medieval structures have bays rectangular in plan, and thus if the final 'trumpet' rims are to achieve their full form, an extensive and structurally unstable flat central area is left to contend with.[95] Even when fan vaulting reached its most sophisticated forms in the early sixteenth century, for example at King's College Chapel, Cambridge (1508-1515), and in the retro-choir of Peterborough Cathedral (completed *c.* 1508; Fig. 1.40), one observes the master still struggling with this inherent structural and aesthetic conundrum. In both cases, to allow the rims to meet transversely and avoid the flat central void, the masons truncated the semi-circles longitudinally.[96]

Perhaps because of these structural limitations, for many decades the fan vault lacked successors. In the half century or so after Gloucester, few further examples were constructed.[97] It became a decorative ceiling for small-scale, at times microcosmic, spaces of square-plan bays, such as cloister walks and the ceilings of chantry chapels (Fig. 1.41).[98] As W. C. Leedy's comprehensive catalogue shows, the overwhelming majority of fan vaults span just two to five metres.

With a span of 24ft 6in (7.48m), the earliest surviving masonry fan vault of any scale over rectangular bays is that over the presbytery at Sherbourne Abbey in Dorset (begun *c.* 1425; Fig. 1.42). [99] Significantly, in the context of my argument for the carpenter as pioneer of new forms, the Sherbourne vault was completed decades after Herland's large-scale experiments with the form of fan vaulting at Winchester College and Arundel – both large structures of rectangular bays.[100] Robert Hulle (d.1442) was the master mason at Winchester College in the early fifteenth century and must have been

[95] Clifton-Taylor, 226-227.

[96] This was a common solution. Further early C16 examples: Henry VII's Chapel, Westminster Abbey; Bath Abbey throughout.

[97] Leedy states that no fan vaults were built between 1412 -30, 11.

[98] The span of the Gloucester cloister is only 12ft (3.66m).

[99] Wilson, 211-212. Doubts may be raised, however, as to whether the Sherbourne vault, with its polygonal in section 'conoids', and its discrete ribs, is truly a fan vault of slab construction (discussed below). Although Leedy includes it in his catalogue, he describes Sherbourne as 'a lierne vault to which the appearance of a fan vault has been applied', 11-12.

[100] See Christopher Wilson's brief comments on Herland's Winchester vault in 'Rulers, Artificers and Shoppers: Richard II's Remodelling of Westminster Hall, 1393-99', in Gordon, Monnas & Elam (eds.) *The Regal Image of Richard II and the Wilton Diptych* (London: Harvey Miller, 1997), 58.

familiar with Herland's large-span vault. If, as John Harvey contends, Hulle was also responsible for the fan vault sixty miles away at Sherbourne, then it is logical to assume that the carpenter's wide vault in the Winchester chapel was not without influence upon the mason as he attempted the first large-scale masonry fan vault.[101]

Whether Winchester is a source for the Sherbourne vault or not, the chapel vault show an inquisitive carpenter experimenting with form and structure. As the masons at Cambridge and Peterborough would later understand, Herland realised in his timber counterparts that perfect semi-circular rims must be compromised if the aesthetic of the fan vault was to be applied to grander structures of rectangular bays. Thus, at Winchester, to allow them to meet transversely, the conoids are elongated into ovoid forms, which maintain the central rhomboid spandrels; at Arundel, Herland squared off his conoids, terminating them in transverse and longitudinal ridge-ribs (Fig. 1.25). Particularly at Arundel, Herland was taking advantage of the lightness and tensile capacity of carpentry. The profile of the Arundel vault is so flat that one may surmise it unlikely that a masonry counterpart could be constructed without danger to the worshipers below.

To summarize the preceding, therefore, it would appear that in the late-fourteenth century the application of the fan vault to large-scale masonry structures had not even begun. After initial experiments with the tester of Edward III, the Winchester and Arundel vaults are Herland's essay on how the structural problems associated with the new style could be solved, and its aesthetic potential might be unlocked for wide spans. Taking advantage of the tensile strength of timber construction, Herland adapted the fan vault form to a then unprecedented scale. Indeed, of the one-hundred and thirty extant fan vaults, only four others exceed the 30ft (9.15m) span of Herland's Winchester vault: the choir and crossing at St Georges Chapel (around 36ft / 11m); Henry VII's Chapel in Westminster Abbey (35ft 8in / 10.58m); and Kings College Chapel (41ft 6in /12.66m) – all constructed around a century later. Herland's vaults, then, stand testimony to the carpenter as a pioneering, innovative and artistically creative craftsman.

---

[101] Harvey (1978), 222; *EMA*, 152.

PENDANTS

Henry VII's Chapel at Westminster Abbey (*c.* 1503-09) arguably contains the apogee of the fan vault, and it was also a vault which included the pendant boss as a major decorative motif.[102] The pendant boss might appear a development with its origins entirely in masonry, the culmination of fan vaulting design in an apparently gravity-defying construction of dazzling conception. An ornamental technique usually applied to buildings of high status, Oxford University's Divinity School (1479-83) is the earliest masonry structure of any significant scale to employ pendant bosses in England (Fig. 1.44).[103] Yet, even in the evolution of this advanced masonry vault, the carpenter may have played a key and early role, if not in developing its structure, then in promulgating the pendant form. The reader may also be relieved to learn that, in a thesis primarily about hammer-beam roofs, this pinnacle of the carpenter's art finally enters the discussion.

The shores of the Moray Firth nearly six-hundred miles north of Westminster Abbey seem an unlikely place to look for a carpentered stimulus for the masonry pendant boss. Yet in the great hall of Darnaway Castle, constructed in 1387d, almost a century before the masons at the Oxford Divinity School embarked on their confection, is a roof crammed with visually imposing pendant forms (Figs. 1.45 & 1.46). Two of the seven cross-frames of this complex and audacious display roof include mechanically redundant pendant king posts. All of the cross-frames contain pairs of inclined pendant posts framed into the soffits of what would be the upper arch braces of a conventional arch-braced hammer-beam roof. It is important to stress that these are primarily

[102] The earliest surviving pendant-boss vault in England is found in the east end of St Mary's Church, Warwick. There, in the micro-architecture of the Dean's Chantry Chapel (1441-52), with inclined pendant bosses perpendicular to the pitch, is a 'toy' fan vault, Harvey (1978), 223 (my Fig. 1.42).

[103] This discussion is limited to the bay-defining *pairs* of pendant bosses found in English rectangular plans. The earliest use of the masonry pendant boss was probably in St Catherine's Chapel (*c.* 1340, destroyed) at Strasbourg Cathedral. They were later used by Peter Parler at Prague Cathedral (e.g. the Sacristy, 1356–62). Here they are used singly in square bays, and rely on a core of ironmongery for their stability, Wilson, 227-229. English carpenters had been experimenting with pendant forms throughout the fourteenth century in church furnishings. For example: sedilia, Westminster Abbey, 1308; Bishop's throne, Exeter Cathedral, *c.* 1316; chancel screen, Lavenham, Suffolk, 1330-40; choir stalls, Lincoln Cathedral, 1370s, Chester Cathedral, 1380s + pulpitum; tester, Edward III's tomb, Westminster Abbey, 1375.

aesthetic, structurally superfluous if not structurally compromising, components. The Darnaway roof thus demonstrates a shift in priorities on the part of the carpenter - from strictly functional to more formal considerations, and the result here is a structure of considerable visual sophistication. On an overt level, the repeated structural motifs display the carpenter improvising around the great aesthetic emblems of the age – the trefoil and cinquefoil. But in this hunting lodge, these forms also repeatedly evoke a taut crossbow, ready to be discharged to dispatch the quarry.[104] Further, the ends of these pendant posts and the hammer-beam serve as repositories of ornament, in the form of rustic carvings of fantastical beasts.[105]

No direct developmental link can be established between a fourteenth-century Scottish hunting lodge with its robustly masculine carpentry and a fifteenth-century hall in an Oxford college. Indeed, with no known derivatives, the roof appears to have been a structural hybrid. The only conclusion to be drawn from Darnaway is this: in the late fourteenth century, Scottish carpenters were experimenting with ornamented pendant forms, notwithstanding any risk to structural soundness, in order to enhance the appearance of a roof in a high-status building.

The fifteenth century was well underway before English carpenters experimented with pendant forms in order to enrich a roof space. Particularly in Suffolk, carpenters began to incorporate bay-defining pendants into the then well-established carpentry of the hammer-beam roof. It was not, however, the insertion of the earthly motifs of the hunting lodge which precipitated this structural experimentation. Suffolk carpenters had more celestial ends in mind. Their pendant hammer posts permitted the proliferation of devotional imagery and foliate motifs, by providing added, more conspicuous locations for such carved ornament. Tostock Church (mid fifteenth-century) is a particularly fine example of pendant technique, and significantly, it

---

[104] For the use of crossbows in medieval hunting see T. McLean, *The English at Play in the Middle Ages* (Windsor Forest: Kensal, 1983), 37, 43.

[105] Geoffrey Stell & Michael Baillie, 'The Great Hall and Roof of Darnaway Castle, Moray', in W. D. H. Sellar (ed.) *Moray: Province and People* (Edinburgh: Scottish Society for Northern Studies, 1993), pp. 163-86; Geoffrey Stell, 'Timber in Scottish Historical Buildings', in Janet Kleboe (ed.) *Timber and the Built Environment* (Edinburgh: Historic Scotland, 2004), 19-26.

predates the Oxford the Divinity School, the mason's first large-scale attempt at pendants, by some two decades.[106] Other fine examples of carpentered pendant hammer-post roofs, with similar ornamental intent, are found in churches at Tostock (mid fifteenth-century), Cotton (*c.* 1471), Wetherden, Grundisburgh (both late fifteenth-century); and in Essex at Gestingthorpe (1489) and Castle Hedingham (early sixteenth-century) (Fig. 1.47). Grundisburgh is a composition of some sophistication (see Fig. 8.51). The receding forms created by the arch-braces of the initial truss and the collar of the subsequent truss are such that each angel appears to reside in its own, individual, domical niche. The Great Hall in the Royal Palace at Eltham (now Greater London) contains a magnificent, if structurally suspect, rare example of the pendant hammer-post roof dominating a secular space.

Detailed analysis of these roofs is reserved for the final chapter of this thesis and its discussion of the development of post-Westminster Hall hammer-beam roofs. Sufficient for the current argument regarding the carpenter as a pioneer of new forms is the following. Pendant hammer-post construction was a minor, late-medieval variation on the theme of the hammer-beam roof. Comparing the dates of the earlier structures, it appears that the wood-wright was the pioneer of the pendant form, the mason finding inspiration in the carpentered development. Further, pendant hammer-beam construction was not the product of the artisan concerned merely with constructing a watertight shelter for benefit of the parishioners. Rather, it is evidence of even the local carpenter becoming an artist, and prioritising visual enrichment over structure.

THE CARPENTER: HIS RIGHTFUL PLACE IN MEDIEVAL ARCHITECTURE

It is reasonable that the work of the mason takes precedence in the study of medieval architecture, and this introduction has not been about usurping the mason's position. After all, in the overwhelming majority of major, high-status works of medieval

[106] The nave was remodelled in the mid fifteenth century. It seems logical to conclude that the roof was erected at the same time. Date: *NHLE*.

architecture, stone is the medium. The purpose of this chapter is to further validate carpentry as a field worthy of serious study – both from a technical and aesthetic perspective. I have attempted to place the carpenter in his proper rank in the medieval building tradition; to assign him his *due* worth; nothing more. Yet it is vital to acknowledge that without the ingenuity of the carpenter, the architectural and engineering feats of the Middle Ages could not have been accomplished. At the very least, during the initial stages of any major medieval construction project the dialogue between Master Mason and Master Carpenter must have been intense. The carpenter was no artisanal second-rater, in thrall to the more intellectual mason, and he was no banausic menial. On countless occasions the carpenter displayed himself as an artist, capable of conceiving structures of outstanding visual sophistication. Acquiring these perceptions, however, requires discernment. The mason's work is patent and perceptible; the carpenter's less so. It is often hidden, ephemeral, or antiquity has rendered it coarse.

I have introduced the theme of hammer-beam roofs, and this is the branch of carpentry that will form the meat of this thesis. With due respect paid to Ely, the hammer-beam roof became the ultimate expression of both the carpenter's technical expertise and artistic creativity. It is the development and culmination of this form which now comes under scrutiny.

Chapter 2

TRUTH, FALSEHOOD AND PENDANT POSTS: WHAT IS A HAMMER-BEAM ROOF?

Introducing the topic of hammer-beam roofs into a conversation elicits a variety of responses. Indifference and ignorance, or curiosity and vague awareness are the most common. The more architecturally cognizant will know the term, but knowledge is limited, and, if they know one example, it is Westminster Hall (begun 1393; Fig. 2.1). With interested parties, discussion and a more detailed definition may follow. In some circumstances, however, the definition of a 'hammer-beam roof' will depend on to whom they were talking. For, as we will discover throughout this chapter, the taxonomy of roof carpentry is contentious ground, and the ostensibly simple procedure of defining a hammer-beam roof is boggier than may be assumed. Indeed, only three structures exist in the whole of Britain that all scholars would agree are true hammer-beam roofs.[1] What for some commentators is simply a 'hammer-beam roof', is for others a 'false' hammer-beam, or even consigned to the entirely different category of an 'arch-braced' roof. Indeed, the nature of 'true' and 'false' hammer-beams continues to be a focus of debate between critics from archaeological and art-historical backgrounds.[2]

This chapter will investigate some of those contentions. To those with little knowledge of medieval carpentry and roof systems much of the following may seem arcane and pedantic. I maintain, however, that before I proceed to the typology and chronological development of the hammer-beam roof, it is important to define what one

[1] Discussed in detail in Chapter 4.

[2] During a question and answer session at the conclusion of the lecture, 'Structural Trends in Medieval Roofs: New Insights from Dendrochronology,' a brief but heated exchange erupted between the speaker R. A. Meeson and Prof. Lynn Courtenay regarding whether Westminster Hall was or was not a 'false' hammer-beam roof. Meeson is formerly a county council archaeologist and Courtenay formerly with the Department of Art History, University of Wisconsin Madison. Vernacular Architecture Group: Winter Conference, University of Leicester, 7/12/2012.

means by the term 'hammer-beam'. Scholars have applied the term both vaguely and with exhaustive (and exhausting) exactitude. Thus, in this chapter previous definitions of a hammer-beam roof are examined and critiqued, and I grapple with the more challenging question of just why some hammer-beams are adjudged 'true', and others 'false'. Having paid due respect to dictionaries and glossaries, the most vital source material, however, consists of the structures themselves. So in order to establish why contentious categories have been established, this chapter includes an analysis of hammer-beam types. At the conclusion the material will be distilled into a clear definition of a hammer-beam roof from which the thesis may proceed. To the best of my knowledge, much of the material, especially the examination of 'true' and 'false' hammer-beams, is original.

FUNDAMENTALS: DEFINITIONS OF A HAMMER-BEAM ROOF

The etymon of the term 'hammer beam' is unknown. George Ellis, carpenter and author of carpentry manuals, concluded in 1906 that 'hammer' beam was a corruption of 'hanger' or 'hanging' beam.[3] This seems entirely plausible, as hammer beams are indeed cantilevered members 'hanging' over voids, but unfortunately Ellis offered no corroborative evidence. Illiterate and literate medieval carpenters used the term - as the accounts from the construction of the Great Hall of Hampton Court confirm (comp. *c.* 1536). The spelling may vary - 'hamer beam', 'hammer beam', 'hammerbeame' – but the term is always distinguishable.[4] Carpenters, then, of necessity possessed the determiner for an important component, and on-site confusion was thus avoided.

Turning to formal works of reference, the *Oxford English Dictionary* is incorrect in ascribing the first dictionary definition to Peter Nicholson's *The New Practical Builder, and Workman's Companion* of 1823.[5] A definition of 'hammer beam' was published four years earlier in a prior work by Nicholson, his exhaustive, *An*

[3] George Ellis, *Modern Practical Carpentry* (London: Batsford, 3rd ed., 1927), 77. First edition is 1906.
[4] Salzman, 217-218.
[5] *OED Online* < http://oed.com > accessed 10/12/2011.

Architectural Dictionary, Containing a Correct Nomenclature and Derivation of the Terms Employed (1819). As it is the earliest, it is worth quoting in full:

> A transverse beam at the foot of a rafter, in the usual place of a tie. Hammer-beams are constructed in pairs, having each a beam disposed on opposite sides of the roof. They are chiefly used in roofs constructed after the Gothic style; the end which hangs over being frequently supported by a concave rib, springing from the wall as a tangent to the curve, and in its turn supporting another rib forming a Gothic arch with the counterpart. The ends of the hammer-beams are decorated with various whimsical devices.[6]

Nicholson here is primarily concerned with the form of the hammer-beam roof, and that form is 'Gothic'. By any modern classification criteria, therefore, Nicholson incidentally places the origin of the hammer-beam in its correct developmental period of the later Middle Ages. The reader, however, gains little inkling regarding structure, or how that structure is intended to function. Indeed, Nicholson writes that the hammer beam is 'in the usual place of a tie', without any hint as to how two discrete timbers might replace one tensional timber which has a crucial tying function. Misleadingly, his later 1823 definition implies that the hammer beams are tie beam substitutes: 'A short beam projecting from the wall at the foot of a principal rafter in a roof, in place of a tie beam.'[7] As will be explained later in this thesis, carpenters did not conceive the hammer-beam as a structural replacement for the tie beam. Considering the rudimentary understanding

[6] Vol. II, p. 70. Batty Langley defined a 'hammer-beam' in 1736 in *Ancient Masonry, Both in the Theory and Practice* … (London: printed for J. Milan; and J. Huggonson, 1736), Vol. I, pp. 367, 370; Vol. II, pl. ccclxxxvii. His definition, however, bears no relationship to the modern understanding, that of a pair of transverse cantilevered timbers in an open roof. Oddly, after over a century Langley's definition was returned to by Prof. John Robison in 1859, who referred to hammer-beams as low-pitched transverse 'stretchers' (struts), connecting the foot of the principal to a low-placed collar, John Robison, [also F. price and T. Tredgold], *A Rudimentary Treatise on the Principles of Construction in the Carpentry and Joinery of Roofs* (London: John Weale, 1859), 80.

[7] *The New Practical Builder, and Workman's Companion* (London: printed for Thomas Kelly, 1823). See also Salzman, 218, for contemporary references.

of structural theory in the early nineteenth century, however, Nicholson may be forgiven.[8]

A substantial number of carpentry manuals were produced in the eighteenth century, so Nicholson's definition is surprisingly late.[9] The first writer to show any awareness of the qualities of medieval carpentry, and hammer-beam roofs in particular, was himself a carpenter, James Smith. Smith's *A Specimen of Antient Carpentry, Consisting of Framed Roofs, Selected from Various Antient Buildings …* (1736), is a pictorially extensive, if verbally limited, appreciation of 'notable' roof carpentry. Smith was clearly impressed by hammer-beam construction, as out of thirty-five illustrations of 'antient' timber roofs, twenty-three are hammer-beams. Yet Smith does not use the term 'hammer-beam', let alone define it.[10]

Just two years after Nicholson's publication, Robert Stuart, in his *A Dictionary of Architecture …* (1825), also gave the term 'hammer beam' its own entry. In a definition which manages to blend patency and opacity, Stuart identified the component as 'a Beam in a Gothic roof, not extending to the opposite side.' He qualifies this sentence with 'a beam at the foot of a rafter.'[11] Of note is that Stuart also locates the hammer beam historically, defining it as 'Gothic'. At the end of the first quarter of the nineteenth century, therefore, the hammer beam was recognised as a form of construction belonging to the Middle Ages. Also of note is that the above dictionaries only define the timber

[8] Discussions of structural theory and, attempts to theorize and understand the forces in roof geometry gathered pace in the late eighteenth century, with Nicholson himself *The Carpenter's and Joiner's Assistant* (1797), and into the nineteenth century with Barlow: *An Essay on the Strength of Timber* (1817); see David Yeomans, *The Trussed Roof: Its History and Development* (Aldershot: Scholar Press, 1992), 164, 165.

[9] Even the exhaustive *The Builder's Dictionary: or, Gentleman and Architect's Companion* (London: printed for A. Bettesworth, C. Hitch & S. Austen, 1734), while including a lengthy entry on 'beam', fails to mention the hammer variety, (or indeed 'hammers').

[10] James Smith (dates unknown), *A Specimen of Antient Carpentry, Consisting of Framed roofs, Selected from Various Ancient Buildings …* (London: for the author, 1736), unpaginated. This work is discussed in more detail in Chapter 3. *A Specimen* was not the first book Smith had published. His *The Carpenters Companion* (1733) was a manual for the 18^{th} century carpenter, the plates consisting of designs for modern roofs.

[11] Robert Stuart, *A Dictionary of Architecture: Historical, Descriptive, Topographical, Decorative, Theoretical, and Mechanical … Familiarly Explained, and Adapted to the Comprehension of Workmen* (London: Jones & Co. 1825), unpaginated.

component: the 'hammer beam' (see Fig. 2.2). They fail to consider the hammer-beam *roof* as a type, a distinct and innovative structure worthy of inclusion in its own right.

The first study of hammer-beam roofs in any detail was that of J. Arthur and Raphael Brandon (1849).[12] Like Smith, the Brandons were admirers of the form, and in *The Open Timber Roofs of the Middle Ages* they describe and depict a selection of mainly ecclesiastical roofs in the south-east of England. In common with Nicholson, the identifying feature of their hammer-beams is indeed 'beams projecting from the walls', the braced horizontal timbers, of varying lengths, extending beyond the inner plane of the wall which decrease the span of the roof. It is with the Brandons that the hammer-beam *roof* is first treated as a distinguishable whole, and thus a definable type meriting study. The Brandons went on to sub-divide the hammer-beam roof into four categories, and their writings are discussed later in this thesis.[13]

Turning to late twentieth-century architectural dictionaries, all continues to seem unequivocal. Following the example of the Brandons, a modification with respect to the earlier dictionaries is that, in addition to defining the individual components, the hammer-beam is confirmed as a distinct roof-type. A further refinement is that the 'bracket', of wall post, hammer beam and hammer brace (see Fig. 2.2), comes to the fore as essential to hammer-beam construction. These brackets, their upper surfaces at wall plate level, support the hammer posts and their associated timbers. The tie beam is absent, and Westminster Hall (Fig. 2.1) is the paradigm.[14]

The specialised twentieth-century literature is more detailed and concomitantly more confusing for the general reader. The academic and former architect R. W. Brunskill defined the hammer-beam frame in 1999 as, 'a roof truss making use of hammer beams and hammer posts and their attendant braces and arch braces', leaving

[12] 1st ed., 1849. The edition used throughout this thesis is, London: James Rimmell & Son, new ed., 1873, henceforth: 'Brandon.'

[13] Brandon, 20-25.

[14] Henry, J. Cowan & Peter R. Smith, *Dictionary of Architectural and Building Technology*, (London and New York: Elsevier Applied Science Publishers, 1986), 122. John Fleming; Hugh Honour; Nikolaus Pevsner, *The Penguin Dictionary of Architecture and Landscape Architecture* (London: Penguin, 5th ed., 1998), 486, 487.

the reader to look up those individual components.[15] Helpfully, he adds this useful aid to visualisation: 'The hammer-beam roof truss has the appearance of a tie-beam truss with the central part of the tie beam cut away.'[16]

Brunskill's work is of necessity well-illustrated, and Professor N. W. Alcock et al., in their slim volume for the Council for British Archaeology (1996, henceforth known as CBA), eschew completely a verbal definition of a hammer-beam roof (they define the individual components), and rely simply on a graphic representation, with its complement of beams, posts and braces (Fig. 2.3).[17] The observant and informed reader will notice structural differences between the hammer-beam roofs depicted in Brunskill (similar to my Fig. 2.2) and that of the CBA. These differences will be considered later. At this point in defining the hammer-beam roof, however, especially for the architectural dilettante, all appears reasonably clear and uncontentious. And yet, turning away from the medium of the architectural dictionary, the first seeds of nomenclatural confusion had already been sown in the nineteenth century.

What is a Hammer-Beam: Ambiguities

The minor Victorian architect Thomas Morris, writing some two decades after the publication of the Brandons' work on ecclesiastical roofs, concentrated on secular buildings. It is in Morris's work that we first scent the taxonomic contentions that were to come. Although *Brief Chapters in British Carpentry* (1871) depicts roofs that would fulfil the hammer-beam criteria of Brandon, Brunskill and the CBA, Morris reserves the term for one only: Westminster Hall.[18] Morris goes on to discuss the highly ornate roof in the Great Hall at Eltham Palace, Greenwich (*c.* 1479, figs. 50 & 51), a structure

[15] R. W. Brunskill, *Timber Building in Britain* (New Haven and London: Yale University Press, 2007), 133.
[16] As noted above, for visualisation purposes only, the tie beam has no structural correspondence with the hammer beam.
[17] N. W. Alcock *et al.*, *Recording Timber-Framed Buildings: an Illustrated Glossary* (York: Council for British Archaeology, 1996), F8. Henceforth: 'CBA'.
[18] Thomas Morris, *Brief Chapters on British Carpentry: History and Principles of Gothic Roofs* (London: Simpkin, Marshall & Co., 1871), 35-52.

universally acknowledged to be a hammer-beam roof.[19] Yet, in his excoriating précis of the roof's structural defects, he spurns the term.[20] Other roofs now considered hammer-beams, such as the former dorter (dormitory) of Westminster Abbey (possibly mid-fourteenth century; subsequently the main hall of Westminster School), Morris dubs simply 'bracket' roofs (Fig. 2.4).[21] One might understand his use of this prosaic term with regard to the ingenuous structure of the dorter, yet Morris's 'bracket' roofs also include the Brandons' highly worked and ornate ecclesiastical hammer-beams of East Anglia. Morris does not explain his taxonomical idiosyncrasies.

The topic of nomenclatural confusion has been introduced, so it should be stated that many 'hammer-beam roofs', including all the church hammer-beams discussed by the Brandons, would not be defined as such by many modern scholars. A further examination of the diagrams of the CBA, in a book that set out to 'introduce logic, clarity and simplicity' into a confusing field, indicates why. Scrutiny of their illustration reveals a preceptive diagram which dictates that the hammer-beam frame must have a precise form (Fig. 2.3).[22] It has the characteristic lower bracket of modern architectural dictionaries, composed of hammer beam, wall-piece and hammer brace, but it is the construction above these brackets that, for the CBA, is determinative of hammer-beam carpentry. As may be seen from Fig. 2.3, the hammer post rises to support, not a rafter, as in the illustrations of Brunskill, and Honour, Fleming and Pevsner (see Fig. 2.2), but a square-set plate, reminiscent of the arcade plate of a timber medieval aisled hall (see Figs.

---

[19] I discuss the structure of this roof in Chapter 8.

[20] Morris, 74-78.

[21] Morris, 91-97. The roof was destroyed in the blitz. The date of the roof is uncertain and has been ascribed by scholars to various dates from the late 13th to the late 16th centuries. In 1933 Lawrence Tanner dated it to 1449-50, after brother George of Norwich set fire to the original roof, 'Westminster School', *Country Life*, Vol. 74 (1933), Dec. 2, p. 593. Anthony Emery suggested a date of *c.*1300 – which would make the roof very early and important - after a previous fire, *Dartington Hall* (Oxford: The Clarendon Press, 1970), 241, 242.
The picture is further confused by the fact that a hammer-beam still exists above the neighbouring room of the chapter library. This is of a different design to its destroyed neighbour; Emery dates this structure to mid C15; EH date it to the fourteenth century (*NHLE*). See also Pevsner, *The Buildings of England*, *London 1* (Harmondsworth: Penguin, 3rd ed., 1973), p. 478.

[22] CBA, F8, B

2.10 & 2.11). A tie beam is framed transversely into this plate.[23] The hammer post is jowled (flared), and tie beam appears to be jointed into both these timbers by means of the ubiquitous three-way post-head joint of medieval and early modern English carpentry, the ingenious tying joint often banally designated: 'normal assembly' (Figs. 2.5 a & b).[24] Above, resting on the tie beam, is an archetypal thirteenth and fourteenth-century crown-post configuration. As will be explained later, the above construction is intrinsic to the narrow definition of a 'true' hammer-beam roof applied by some scholars.

By contrast, most of the examples of hammer-beams provided by Brandon, the bracket roofs of Morris and the depiction by Brunskill differ radically from the above singular definition. These simpler structures feature hammer posts that mainly rise to support a principal rafter, and tie beams and 'normal assembly' are replaced by collars and alternative jointing techniques (see Fig. 2.2). Such configurations are typical of the East Anglian roofs which form one of the core topics of this thesis. The mode of construction of such roofs appears not to fulfil the strict criteria for hammer-beams prescribed by the CBA - which begs the question: what are they? It is here that the student of the hammer-beam must confront the test of intellectual tenacity that is the debate concerning 'true' and 'false' hammer-beam roofs.

Below what one should now call the 'true' hammer-beam (Fig. 2.3), the CBA depict this 'false' contender (Fig: 2.6).[25] Here, form takes precedence over structure. Visually, rather than the massive assemblage of timberwork in the 'true' form, the form of an arch dominates the structure, the principal rafters appearing to rest on arch braces rather than posts. The authors clearly want to include the East Anglian roofs in this 'false' category, as their example shows the structure and high degree of ornamentation characteristic of these roofs – even having the commonly-found carved angels on the

[23] I think the 'tie beam' in an aisled building ought more aptly be designated a 'collar beam', but I am in the minority.

[24] CBA, F2; Brunskill, 152. 'The perfect timber frame joint', American carpenters call this the 'English tying joint'. It solves the problem of jointing wall post, wall plate and tie beam (possibly also a principal) at the same point, without removing excessive timber which would weaken the joint. Steve Chappell, *A Timber Framer's Workshop* (Brownfield, Maine: Fox Maple press, 1998) 170; Jack Sobon; Roger Schroeder, *Timber Frame Construction* (North Adams, Mass.: Storey, 1984), 28, 194.

[25] CBA, F8, D.

hammer-beam ends. Structurally, this illustration corresponds with major fifteenth-century East Anglian examples, for example the principal frames of St Mary's, Bury St Edmunds, and St Mary Magdalene, Little Welnetham, Suffolk (Fig. 2.7).[26] Nonetheless, both roof types depicted on the same page in CBA have hammer beams and the dictionary determinant lower bracket, so why, with their pejorative implications, is one labelled 'true' and the other 'false'? To reiterate, if one followed the CBA's criteria, the majority of hammer-beam roofs, including *all* the splendid East Anglian examples, would be designated as 'false.'

The answer lies in the debate concerning the origin of the hammer-beam roof: just when, in what type of building, and in what form did hammer-beam construction first occur? This will be the subject of a more detailed treatment later in this thesis. For now, I will consider the *debate* surrounding the origin of the hammer-beam roof, and its relevance to the awarding of 'true or 'false' status.

TRUE V FALSE: ORIGINS OF THE HAMMER-BEAM ROOF

For decades, from the Brandons forward, it was simply stated that the hammer-beam roof had its origins in the common rafter roof: the result of the simple expedient of elongating the sole piece and a concomitant ingression of the ashlar piece (Figs. 2.8 & 2.9).[27] These two members, along with the rafter, make up the rafter 'foot'. This configuration became widely adopted during the medieval period, particularly for use on masonry walls, as medieval carpenters discovered its effectiveness in increasing stability and reducing lateral thrust.[28] According to the Brandons, extending the sole and ashlar pieces beyond the internal plane of the wall, increasing their scantling, and then fitting a wall post and brace to form the lower bracket, created the basic component of the hammer-beam frame.

[26] In the same county, Church of St Peter and St Paul, C15, Fressingfield.
[27] Brandon, 22.
[28] The effectiveness of this simple construction will be demonstrated by means of a model the next chapter.

The first serious twentieth-century student of medieval roofs, F. E. Howard, although critical in many respects of the Brandons, agreed with their explanation of the genesis of the hammer-beam. Writing in 1914, he excluded other possible origins: 'When the sole piece projects from the wall it is called a hammerbeam … the invention of the sole-piece … made the discovery of the use of the hammerbeam inevitable.'[29] The mid twentieth-century architect and East Anglian church authority H. Munro Cautley concurred: 'the hammer-beam is really the sole piece of earlier roofs, projected into the church and with the wall-post and bracket [hammer brace] tenoned into the underside'.[30] This view persisted throughout the century, and although in reality only an assumption, it was presented in peremptory manner. In 1984, the academic and medieval roof specialist Lynn T. Courtenay commented that 'it is generally agreed that the so-called "hammer-beam" truss evolved as an extended solepiece connecting the inner face of the wall with the exterior.'[31]

From the mid-twentieth century onwards, however, other researchers, mainly from an archaeological background, were preaching a different evolutionary node for the hammer-beam: the archetypal domestic building of status during the later medieval period, the aisled hall (Figs. 2.10, 2.11 & 2.14).[32] J. T Smith, writing in 1970, dismissed the

[29] F. E Howard, 'On the Construction of Medieval Roofs', *Archaeological Journal,* Vol. 71, 1914, p. 318.

[30] H. Munro Cautley, *Suffolk Churches and their Treasures* (Woodbridge: The Boydell Press, 5th ed., 1982), 93. Also, John H. Harvey, *Gothic England* (London: Batsford, 2nd ed., 1948), pp. 51, 52. Edward T. Long in 'Painted Roofs in East Anglian Churches', *The Burlington Magazine for Connoisseurs*, Vol. 55, No. 317 (Aug., 1929) wrote 'It is, in reality, merely the lengthening of the sole piece or cross wall-plate to which the principal rafters are fixed in double-framed roofs.' p. 75.

Many of these critics were perhaps influenced by a drawing in Villard De Honnecourt's sketchbook (compiled *c.* 1220-40), of a 'good light roof' which shows an extended sole plate arrangement. It lacks, however, the lower bracket crucial to the hammer-beam roof. J. B. A. Lassus and Alfred Darcel, *Album de Villard de Honnecourt* (Paris: Imprimerie Imperiale, 1858), pl. 33; the original document is in the Bibliothèque Nationale de France (MS Fr. 19093).

[31] Lynn T Courtenay, 'Westminster Hall and its Fourteenth-century Sources', *Journal of the Society of Architectural Historians*, Vol. 43, No. 4 (Dec. 1984), 296, nt. 11. See also Courtenay, 'Where Roof meets Wall: Structural Innovations and Hammer-beam Antecedents', in Pamela O. Long ed., *Science and Technology in Medieval Society* (New York: The New York Academy of Sciences, 1985), 90. I review Howard's 1914 paper, including his alternative proposal for the origin of the hammer-beam roof, in Chapter 3 of this thesis.

[32] Aisled halls probably existed in Saxon times, but they became widely adopted after the Conquest, Margaret Wood, *The English Medieval House* (London: Bracken Books, 1983) 35-48; Anthony Emery, *Discovering Medieval Houses* (Oxford: Shire, 2007), 25. A way of seeing the layout of the timber variant is to visit a

notion that the hammer-beam arose from an ingression of the sole piece and ashlar piece in one footnoted sentence.[33] Rather, he explained, in a milieu of aisled construction, the hammer-beam roof resulted from a new demand on the part of the medieval client for unobstructed floor space. The consequent removal of the arcade posts required radical structural modification if catastrophe were to be averted. The hammer-beam was, Smith contended, one of the key constructions employed by carpenters to achieve such uncluttered internal space while maintaining structural stability (Fig. 2.12 a & b).[34] An exemplar frequently cited as proof of Smith's assertion is a structure located in the close of Winchester Cathedral: the Pilgrims' Hall (1310-11d; Figs. 2.13 a & b).

The Pilgrims' Hall is a cardinal building for studying the origins of the hammer-beam roof.[35] It is purported to contain the earliest example of a hammer-beam roof, and it contains many elements of aisled construction, including in its south-west range a complete aisled cross-frame with posts and aisle ties. [36] The north-east range contains two hammer-beam frames, and the three bays they define are essentially those of an aisled medieval hall *sans* arcade posts. The framing is similar to that of the aisled cross-frame in the hall, except that the aisle posts appear to have been sawn off.

Thus, the Pilgrims' Hall hammer-beams differ from those proposed by the champions of the extended sole-piece derivation. What were regarded as extended sole-pieces may now be seen as transformed aisle ties (compare Fig. 2.14). Once the aisle posts are truncated, these once secondary timbers now become primary - hammer beams -

---

medieval barn. Two fourteenth-century examples are Bredon Barn nr. Tewkesbury, and Middle Littleton tithe barn, nr. Evesham, both Worcestershire.

[33] J. T Smith, 'The Reliability of Typological Dating of Medieval English Roofs', in R Berger (ed.), *Scientific Methods in Medieval Archaeology* (Berkeley Ca.: University of California press, 1970), 255, nt. 30.

[34] J. T., Smith, 'Medieval Aisled Halls and their Derivatives', *Archaeological Journal,* Vol. 112 (1955), 90. J. T. Smith, 'Medieval Roofs: A Classification', *Archaeological Journal*, Vol. 115, 1958, pp. 120, 123, 124.

[35] John Crook is the authority on the Pilgrims' Hall: 'The Pilgrims' Hall, Winchester', *Proc. Hants. Field Club Arch. Soc.*, 38 (1982), pp. 85-101; 'The Pilgrims' Hall, Winchester, Hammerbeams, Base Crucks and Aisle-Derivatives', *Archaeologia* 109 (1991), 129-159. Useful also is Walter H. Godfrey; J. W. Bloe, 'Cathedral', *VCH Sussex*, Vol. III, ed. L. F. Salzman (1935), pp. 105-169.

[36] In most of the literature Pilgrims' Hall is promulgated as the earliest example of the use of hammer-beam frames. For examples see J. Harvey, *Gothic England* (1948), 51; Emery (1970), 238; Courtenay (1984), 296, nt. 11. John Crook (1991) reported the tree-ring date of 1308d. I discuss other contenders for the earliest hammer-beam roof in Chapter 4 below.

massively proportioned and braced to withstand the radically different structural demands placed upon them by the hammer post.[37] The hammer posts rise to support a square-set arcade plate typical of aisled framing, and, not the principal rafter or collar of the typical extended sole piece-derived roof, but a tie beam.[38] This tie beam maintains its traditional thirteenth-century function and supports a self-contained (if small-scale) crown-post and common rafter roof. The carpentry of the Pilgrims' Hall is monumental, of heavy timbers, described by some as crude.[39] East Anglian hammer-beam roofs are clearly not derived from aisled construction, and J. T. Smith went on to dismiss such carpentry as 'merely forms of strutting designed to keep the principal rafter rigid, or, in some cases, are purely decorative.'[40] Dismissal declines into denigration in D. F. Stenning's brief appraisal of such fifteenth-century hammer-beams. Not merely 'false', they are 'debased.'[41]

The carpentry of Pilgrims' Hall, allied with its early date, appears to prove, therefore, J. T. Smith's contention that the hammer-beam roof is derived from aisled hall carpentry. Further, the above description of Pilgrims' Hall will be familiar to the attentive reader, as the hammer-beam frames there are virtually identical to the CBA's illustration of the 'true' hammer-beam (Fig. 2.3). For the CBA, then, the 'true' hammer-beam roof is rooted in aisled construction. The following logic, then, seems to apply: Pilgrims' Hall contains the earliest known examples of hammer-beam frames, and it is also an aisled structure; the structure of the aisled hall is therefore *the* origin of the hammer-beam roof; any roof that departs in form and carpentry from that structural Adam is 'false'. This begs the question: if an earlier example were found of extended sole

[37] Alternatively, in the type known as the 'raised aisled' hall, the hammer beams may be visualised as a tie beam with the central section excised.

[38] For the medieval house authority Anthony Emery the hammer post, the hammer beam and the square-set purlin are the 'basic combination' of the hammer-beam roof. Emery, however, does not make the distinction between 'true' and 'false' hammer-beams, (1970), 237 and 237-244 *passim*.

[39] Harvey (1948), 51.

[40] Smith (1970), 256.

[41] 'East Anglian Roofs: an Essex-centric View', in John Walker (ed.), *The English Medieval Roof: Crownpost to Kingpost* (Essex Historic Buildings Group, 2011), 40.

piece parenthood, would the descendants of this earlier antecedent assume the mantle of 'true', and their aisle-derived cousins, thus being usurped, dubbed 'false'?

Putting the above question aside, the same fundamentalist approach is followed by Richard Harris in his *Discovering Timber-framed Buildings* (2006), an introduction for the general reader, and further promulgated by J. Crook, in his 1991 archaeological analysis of Pilgrims' Hall for the specialist.[42] Crook concurs with Smith, arguing that the 'true hammer-beam' is the 'most sophisticated' offspring of the aisled hall, the hammer beam component being 'essentially part of a bracket to support a raised [and 'shortened', as he earlier states] arcade post'. Although, strangely, omitting the square set arcade plate, a fundamental component of aisled construction which for many is a key determinant of the 'true' hammer-beam, Crook goes on to outline a limited number of structural details that the hammer-beam bays of Pilgrims' Hall have in common with 'true aisled forms.' He repeatedly asserts that any hammer-beam roof not derived from the aisled tradition is 'false'.[43] Crook even declares 'false' the paradigm of all the dictionaries and the commonly regarded apogee of hammer-beam construction, Westminster Hall.[44] Crook's vague explanation of this assertion is that Westminster Hall has the 'opulent appearance of the hammerbeam roof with the structural stability afforded by huge arch braces,' implying that the Westminster structure functions largely as an arch-braced roof (Fig. 2.15). Ignoring the fact that without its own 'huge arch braces' the Pilgrims' Hall hammer-beams would have little 'structural stability', research published prior to Crook's 1991 study demonstrated the crucial structural role played, not only by the arch braces, but by the hammer beams and posts in the Westminster roof.[45]

---

[42] Richard Harris, *Discovering Timber-Framed Buildings* (Princes Risborough, Bucks: Shire Publications Ltd., 3rd ed., 2006), 10, 11.

[43] Crook (1991), 150-52.

[44] Crook (1991), 152. A view reiterated in 2012 by R. A. Meeson, former President of the Vernacular Architecture Group: VAG Winter Conference, University of Leicester, 7/1/2012.

[45] L. T. Courtenay and R. Mark, 'The Westminster Hall Roof: a Historiographic and Structural Study', *Journal of the Society of Architectural Historians*, Vol. 46, No. 4 (Dec., 1987), pp. 374-393. My own research, discussed in Chapter 6, proposes the structural role of these timbers as intended by the carpenter.

Oddly, however, if the extant examples are anything to go by, the 'true' hammer-beam was something of a developmental dead end. Crook writes that after Pilgrims' Hall and one other early example at the Bishop's Kitchen at Chichester (Fig. 2.14 & 2.15) of *c.* 1300d, which, inconveniently, does not belong to an aisled hall, 'no other true hammer-beam roofs survive until the second quarter of the fourteenth century', adding, 'few, if any, true hammer-beam roofs were constructed after the mid-fourteenth century.'[46] If Crook is correct, then the 'true' hammer-beam is a rare beast indeed, a product of a sixty-year period ending in the mid-fourteenth century. Survivors belong to a very select group.[47]

It should be noted here that the Brandons, as Howard and other early twentieth century commentators, seemed ignorant of the existence of the aisled-derived hammer-beam and so did not posit it as a structural font.[48] And, not all later twentieth-century critics share the reductionist view of hammer-beam construction propounded by Smith, Emery, Harris, Crook and the CBA. Brunskill is less proscriptive; his drawings are generalised, and his representation of a false hammer-beam is, reasonably enough, that of contignation where the hammer-beam contributes little, if any, structural function to the frame.[49] R. A. Cordingley, in his seminal 'British Historical Roof Types and their Members' (1961), also shows a greater degree of tolerance toward whom may or may not be permitted into the hammer-beam fold. Cordingley, in his mainly schematic exposition, avoids the word 'true', but the structure of three of his diagrammatic hammer-beam roofs not judged 'false' can readily be seen in East Anglian hammer-beams.[50] These three examples clearly are not aisle-derived, having hammer posts that rise to support principal rafters rather than arcade plates – anathema to the hammer-

[46] Crook (1991), 151, 152. The Bishop's Kitchen is square in plan with a pyramidal roof.

[47] I am aware of only three extant and one destroyed (but documented) 'true' hammer-beam roofs. All belong to the fourteenth century. They are discussed in Chapter 4.

[48] The roof of the Pilgrims' Hall was first studied in detail by N. H. C. Nisbett in 1894, 'Notes on the Roof of the Pilgrims Hall, Winchester', *Proc. Hants Field Club Archaeol. Soc.* 3, pp. 71-77. The twentieth-century scholars, therefore, had opportunity to acquaint themselves with the aisle-derived nature of this roof.

[49] Brunskill, 133.

[50] 'British Historical Roof-Types and Their Members: A Classification', *Transactions of the Ancient Monuments Society* IX (London: The National Monuments Society, 1961), 89.

beam purist.[51] Cordingley designates the one illustration that closely resembles the aisle-derived hammer-beam not 'true', but a 'hammer-beam queen post truss.'

Cordingley is here displaying a more traditionalist view as to what constitutes falsity in a hammer-beam, for as will now be discussed, many commentators argue that a 'false' hammer-beam has little to do with deviation from the structural bloodline of the aisled hall. It is the mark of architectural duplicity.

FALSE V TRUE: STRUCTURAL HONESTY

The champions of aisled-derivation did not invent the term 'false hammer-beam.' The earliest use of the term is in F. E. Howard's 1914 exposition, and he coined it for use in an entirely different context from that of some debateable developmental node.[52] For Howard, falsity is contingent on the structural role of the timber components. Thus, he applies the term 'false' to configurations where, 'the brace is kept back from the end of the hammerbeam', and when, 'spring[ing] from principal [rafter] the hammerbeam is useless' (Fig. 2.16).[53]

For decades in the twentieth century, this definition of a 'false' hammer-beam as pertaining to the structural honesty prevailed. Writing in 1922, Herbert Cescinsky and Ernest Gribble propagated the view of Howard: 'the hammer-beams, especially the upper tier [in a double hammer-beam] are introduced merely for decorative effect, and the arch-braces bear only at the junction between the hammer-beams and the principals. The hammer beam takes no strain, and fulfils no purpose; it merely projects in to the air, uselessly' (Fig. 2.17).[54] Such upper hammer beams would be incapable of taking any 'strain' anyway. They are of necessity tenoned *into* the principal rather than vice-versa,

[51] Crook (1991), 152

[52] Howard, 320.

[53] Howard, note to his fig. 22. As an example he provides All Saints Church, Tilney, Norfolk (Fig. 2.17).

[54] *Early English Furniture and Woodwork*, Vol. I (London: The Waverley Book Company Ltd., 1922), 60, 62.

and any downward force from the roof would turn this hammer beam into a lever acting on the inadequate resistance of the pegs.[55]

Brunskill, with his somewhat ambiguous drawings and captions of 'false' hammer-beams appears to agree with Howard, and Cecsinsky and Gribble, and it seems intuitively reasonable that a structure with members that are deceptive as to their true function should be deemed 'false'. The fifteenth-century roof of the Church of St Mary, Wetherden, Suffolk, is the quintessence of the above structural deception (Fig. 2.18). It is 'false' in almost every manner: the upper hammer beam has no post, and its hammer brace, springing as it does from the principal rafter, has no mechanical function. The hammer post on the lower tier, being the structurally compromised pendant type, would also be judged 'false' by some observers. [56] 'Beauty and not constructive carpentry was the aim of their designers', Cautley concluded, but despite all this structural fakery, the roof is remarkably well intact.[57]

Such deceit was taken to extremes in later roofs of the late fifteenth and sixteenth centuries, such as the Exeter Law Library (C15) and Cadhay House (C16), Ottery St Mary, Devon (Figs. 2.19-21), structures termed: 'suspended' hammer-beam roofs.[58] Here the hammer beam / hammer post configuration are devoid of structural function. The hammer beam is tenoned *into* the arch rib (Fig. 2.20). In the normal arrangement the arch would be tenoned into the hammer beam, the latter continuing through the wall-plate. Thus, it is the arch rib allied with the principal rafter that is carrying the load, and the hammer beam and post are dangling, decorative features. The evidence of this is at Cadhay, where the hammer beams have been removed, and the roof still stands.[59]

---

[55] Mortice and Tenon joints work poorly in tension. Traditionally they were fixed by wooden pegs. When placed under tension the joint relies only on the relatively thin pegs for its integrity. See fig. 2.5b where the pegs can clearly be seen fixing the foot of the principal rafter, and the top of the wall post, into the tie beam.
[56] Cautley, 94. He echoes Herbert Cescinsky and E. R. Gribble, *Early English Furniture and Woodwork*, 2 Vols. (London: The Waverley Book Company Ltd., 1922) 62.
[57] Cautley, 95. Cescinsky & Gribble have similar reservations about the roof's flaws, 82. A comparable roof is nearby at Tostock, Church of St Andrew, possibly by the same carpenter.
[58] D. F. Stenning, 'The Roof at Dartington Hall', *VA* 29 (1998), p. 97.
[59] Two 14th century examples of this type of purely decorative 'suspended' hammer-beam: Upton Court, Slough, and Gobions, Great Bardfield, Essex; discussed further in Chapter 4 of this thesis.

Thus, it is architectural deception, an inserted timber which merely simulates load-bearing function, which for the above commentators renders a hammer-beam roof 'false'. So disposed, they stand in a long rank of critics from Plato to Pevsner scornful of architectural pretence, 'constructed ornament, by which fiction ultimately surmounted truth.'[60]

Unfortunately, in the 'true' v 'false' arena, even with the introduction of this 'honesty to construction' criterion, the contenders are still not clearly defined. Some critics, Cordingley chief among them, wanted a broader conception as to what constituted a false hammer-beam. His notated diagrams contend that all hammer beams surmounted by curved timbers, rather than clearly defined hammer posts, should render a truss 'false.'[61] (Fig. 2.22) This judgement departs from that of the Brandons, Howard, and Cescinsky and Gribble. The shape of the timbers atop the hammer beam for them was irrelevant; it was their placement, and concomitant structural function that was key. Hammer-beam frames with curved braces rather than posts could still be 'true' as long as these timbers were placed at the end of the hammer beam, thus performing their intended supportive function.

Cordingley's position is odd. Why should the use of a curved timber in this position make the roof 'false'? Structure is explicit. No kind of architectural chicanery is going on. The structural function of the curved timber in this context is little different from that of an arch-braced post. A *combined* post and brace is supporting and bracing the principal rafter and its purlin, just as the braced post of two timbers supports and provides triangulation to the same (compare Fig. 2.23). Cordingley's application of the

---

[60] Thomas Morris, 97. Plato, *The Republic*, trans, I. A. Richards (Cambridge: CUP, 1966), 601, d. A. W. N. Pugin: 'the severity of Christian or Pointed architecture is utterly opposed to all deception', *The True Principles of Pointed or Christian Architecture* (London: John Weale, 1841), 34, also p. 1. John Ruskin in *The Lamp of Beauty: Selected Writings on Art,* ed. Joan Evans, 201-208; Ruskin, *The Stones of Venice*, Vol. III, eds. E. T. Cook, Alexander Wedderburn (London: George Allen, 1904), 428. Alfred Loos, 'Ornament and Crime' (1908), in Ulrich Conrads, *Programmes and Manifestoes on 20th-Century Architecture,* trans. Michael Bullock (London: Lund Humphries, 1970), 19-24. Le Corbusier, *Towards a New Architecture*, trans. Frederick Etchells (New York: Dover, 1986), 90-127. Nikolaus Pevsner, 'Architecture in Our Time', *The Listener*, 5 January 1967, p. 9.

[61] Cordingley, 89.

term 'false' to curved timbers, in lieu of arch-braced posts, merely renders an already difficult field more arcane. Nomenclatural confusion is underlined by the fact that the CBA's 'false' 8D (Fig. 2.6) closely resembles Cordingley's IVd, which carries the appellation 'hammer-beam collar truss', with no qualifying 'true' or 'false'.[62] Before madness ensues from trying to unpick this taxonomical jumble, timely are a few concluding remarks.

After reading this chapter, the reader may agree that the task of defining a hammer-beam roof is not as straightforward as it first appears. Nonetheless, if structural details and recondite terminology are bewildering, it is hoped that the reader will glean an understanding of hammer-beam types: single, double, aisled hall-derived, extended sole-piece derived, etc., and their basic structure.

What conclusions may be drawn from the flotsam of the discussion of 'true' and 'false' hammer-beams? For commentators from a more archaeological background, if a hammer-beam roof is not structurally cognate to the stump from which all hammer-beams sprouted – the aisled hall - it is false. For critics from a technical or architectural history background, a hammer-beam roof is false because the carpenter attempted structural deception. J. T. Smith sniffily remarked that any discussion of 'true' and 'false' hammer-beams was 'otiose.'[63] Nonetheless, the terms still occur in both academic studies and general guides, and the purpose of this chapter was to address problems intrinsic to these judgemental appellations to the end of clarifying a difficult field.[64] For the sake of that clarity, and for reasons which will become clear by the end of this thesis, I reject the term 'true' completely. I am tempted also to consign 'false' to the taxonomical dustbin. Nevertheless, the term is useful, but I limit its use and reserve it strictly for those roofs,

[62] Cordingley, 89.

[63] Pevsner, Enid Radcliffe, *Suffolk* (London: Penguin, 2nd ed., 1974), 66.

[64] For more recent scholars grappling with the distinction between 'true' and 'false' hammer-beam roofs: Jane Grenville, *Medieval Housing* (London: Leicester University Press, 1997). 61, 62, where she refers to 'the confusion of the hapless student' when confronting the issue; and J. Clarke, 'An Early Vernacular Hammer-beam Structure: Imberhorne Farm Cottages, East Grinstead, West Sussex', *Vernacular Architecture* 36 (2005), 37, 39.

such as the Exeter Law Library, in which the hammer-beam framing performs no structural function.

Regarding the initial remarks of this chapter concerning the basic definition of a hammer-beam roof, finding an exemplar has been impossible; all contain their lacks and vagaries. Perhaps the best is in Lynn Courtenay's 1985 paper. 'Brackets' have, rightly, figured large in most modern accounts of the hammer-beam, and Courtenay's is no exception. As she explains, the lower bracket, consisting of hammer beam, wall post and arch brace, 'is almost always present when the hammer-beam frame functions as a principal [frame].'[65] This configuration, then, defines the hammer-beam roof. Other forms have collars, arch braces and square-set plates, but only the hammer-beam has this span-reducing bracket. But even here, Courtenay misses an essential point: this lower arrangement is much more than a mere 'bracket.' In a simple bracket, all timbers are within the inner plane of the wall. Yet the hammer beam continues *through* the wall to have its stability augmented by being pinned by the foot of the principal rafter – a crucial structural ingredient (see Fig. 2.2).

So, in conclusion, I will distil all the arguments of this chapter into a clear and concise definition of a hammer-beam roof. The determinant is simply this: the timber which extends across the wall plate to project beyond the inner plane of the wall: the hammer beam. If a structure possesses this component in its principal frames, it is a hammer-beam roof.

---

[65] Courtenay (1985), 91, 92.

Chapter 3

LITERATURE PERTAINING TO THE CHRONOLOGY AND TYPOLOGY OF THE MEDIEVAL HAMMER-BEAM ROOF

The works reviewed in this chapter span from the middle of the nineteenth century, when the serious study of such structures began, to the late twentieth century and a renaissance in the field of medieval carpentry studies. As I have chosen to concentrate on works which make a significant contribution to the understanding of the hammer-beam roof, a number of important works on medieval carpentry in general have been excluded. Thus, some readers may be surprised to see Cecil Hewett absent from the list of authors. Extensive investigations by the indefatigable Hewett yielded a number of publications, most notably *English Historic Carpentry* (1980) and *English Cathedral and Monastic Carpentry* (1985).[1] While the works of Hewett, especially his drawings, are essential for any student of carpentry development, sparse are his comments on hammer-beam roofs. Other omissions have been made due to exigencies of space. I have chosen not to include Thomas Morris's idiosyncratic circumbendibus, *Brief Chapters on British Carpentry: History and Principles of Gothic Roofs* (1871).[2] Morris does comment extensively on hammer-beam roofs ('bracket roofs' as he dubs them), and while a few of his novel opinions are of interest, his volume is only worth consideration historiographically as a curio. Finally, in the late-twentieth century Westminster Hall became the focus of a small but fervent group of academics. Their inquiries, such as the writings of Jacques Heyman, Lynn Courtenay and Robert Mark, will be reviewed in Chapter 6 of this thesis.

---

[1] *English Cathedral and Monastic Carpentry* (Chichester: Phillimore, 1985)

[2] (London: Simpkin, Marshall & Co., 1871)

THE DRAWINGS OF JAMES SMITH, CARPENTER (1736)

The earliest appreciation of hammer-beam roofs is non-verbal. *A Specimen of Antient Carpentry, Consisting of Framed Roofs, Selected from Various Ancient Buildings, Public & Private ...* (1736) is, apart from a few brief introductory remarks, simply a collection of thirty-nine illustrative plates.[3] Here, among various roof designs including domes and spires, the London carpenter James Smith depicted thirty-five roof frames. Smith was clearly an aficionado of the hammer-beam, as twenty-three of these thirty-five plates are of that variety. The majority of these designs are historic, mainly of the sixteenth century, and they serve well to display how carpenters and designers fully (some may say excessively) exploited the decorative potential of the hammer-beam during that period. Heavy mouldings, serpentine arch braces and pendant posts abound. Voids between timbers are filled with an array of decorative motif, from classical columns (Temple Hall, London, 1573), and Renaissance balusters (Jesus College Oxford, 1571; 24 turned balusters to each truss), to Gothic 'pointed' arcading (Guildhall, London) and traceried spandrels (Lambeth Palace, *c.* 1660, damaged in the blitz, heavily restored).[4] Smith's taciturn work is, then, invaluable as a record of structures now destroyed, some lost to neglect or the caprices of fashion; others to Nazi bombs. For instance, The Savoy in the Strand, London, possessed a particularly ornate hammer-beam, as did the Guildhall and Pinners' Hall of the same city.

A Specimen of Antient Carpentry, is not merely a nostalgic appreciation of the work of Smith's forebears. Smith clearly believed, unlike the earlier writer Joseph Moxon, that the hammer-beam design had validity for use in the eighteenth century.[5] The two hammer-beams Smith designs for modern patrons are, however, far removed from the open roofs of the medieval builders. Interestingly, echoing Villard de Honnecourt, the designs are for trusses over vaulted ceilings, and here Smith clearly

---

[3] (London: printed for the authar [sic], 1736)

[4] The date (and indeed the existence) of the Guildhall hammer-beam as depicted by Smith is uncertain. Possibly post-Great Fire, some scholars think that the hammer-beam depicted by Smith was the original medieval roof of 1411. Caroline Barron, *The Medieval Guildhall of London* (London: Corporation of London, 1974), 28, 29.

acknowledges the hammer-beam, with its central void, as an ideal construction for clearing the extrados of the vaulting of a church.[6] Nonetheless, his designs are entirely modern, with fully developed king and raking struts above the collar *a la* Moxon, and, to ensure structural stability, a full complement of metal strapping.

It is disappointing that Smith did not supply a commentary to go with these drawings. Apart from this slim volume and an earlier carpenters' manual, little is known of the author.[7] Perhaps as a practitioner of the mechanical arts he felt unlettered and inadequate. Nevertheless, his drawings display an inquisitive spirit and an eye for detail, and it is notable that he gave so much attention to hammer-beam roofs. To regard Smith's book as merely some kind of sales-pitch for his carpentry business is to undervalue its worth. Smith includes only two original designs for roofs and these have little in common with the historical roofs he devotes so much attention to in subsequent plates. Rather, Smith's work must be seen - at the risk of sounding patronising - as a naïve form of connoisseurship. Here was an apparently simple craftsman who saw something of significance in these roofs, and took the trouble to publish a pictorial record at his own expense. This rare and ingenuous work, then, proves to be surprisingly important: Smith, through his detailed drawings, is the first to give validity to the carpenter's art as a subject fit for study.

---

[5] Joseph Moxon, *Mechanick Exercises or the Doctrine of Handy-works* (London: Midwinter & Leigh, 3rd ed., 1703). Moxons work, a craft manual covering various trades, was published in instalments in the seventeenth century. His two chapters on 'house carpentry' (pp. 117-144), pay no heed to the work of the medieval carpenter.

[6] Hans R. Hahnloser, ed., *Villard de Honnecourt: Kritische Gesamtausgabe des Bauhüttenbuches* (Graz: Akademische Druck- u. Verlagsanstalt, 1972), plate 33. Bibliothèque Nationale de France (MS Fr. 19093), fol. 17 r.

[7] Smith's earlier book: *The Carpenters Companion: being an accurate and compleat treatise of carpenters works; ... exemplified in forty-one copper-plates; with remarks and descriptions* (London: printed for J. Millan, 1733).

RAPHAEL AND J. ARTHUR BRANDON, *THE OPEN TIMBER ROOFS OF THE MIDDLE AGES*, 1849

Having paid respect to James Smith's volume, any consideration of the literature on hammer-beam roofs must begin with the study by the architects Raphael and J. Arthur Brandon, the incunabula of the scholarship of medieval carpentry: *The Open Timber Roofs of the Middle Ages* (1849).[8] Previous generations ignored, declaimed and destroyed such roofs, lamented by the Brandons as a 'rage of destruction'.[9] Admirers, if they existed, left no record. As their preface confirms, 'the conviction that, of all the various branches of Ecclesiastical Architecture, the Open Timber Roofs of our ancient Churches had received the smallest portion of attention, induced us to undertake its investigation.'

The tone of the work is one of instruction and gentle persuasion. In a period of church-building and restoration, the book is an invitation to contemporary architects not to slavishly copy, but to use the medieval roofs as 'excellent models', 'to give to necessary construction the most beautiful forms'. These 'beautiful forms' were English Gothic, particularly 'Middle Pointed', exemplified by late thirteenth – early fourteenth-century work at York Minster, a form that typified 'the elevating spirit of Christianity.' Fuelled by the writings of A. W. N. Pugin, the Brandons were writing at the end of a decade that saw a crescendo of enthusiasm for Gothic architecture in England. Classicism was despised, its massive, rectilinear beams more in harmony with temples devoted to the 'cold and philosophic worship of Classick Paganism.'[10]

Their 'excellent models' are a number of medieval roofs selected from the south-east of England, principally Norfolk and Suffolk. These are studied with a forensic eye and reproduced in a series of forty-eight plates of meticulous architectural drawings which not only reveal the carpenter as a master of roof construction, but also of exquisite decorative detailing. This is no dry, academic study, however. As displayed by their

[8] This edition: London: James Rimmell & Son, new ed., 1873. First published 1849; henceforth: 'Brandon.'
[9] Brandon, 7. The Brandons also refer to the 'blighting spirit of indifference'.
This destruction was also decried by A W. N. Pugin, *The True Principles of Pointed or Christian Architecture* (London: John Weale, 1841), 41- 42.
[10] Brandon, 3. The Brandons are clearly influenced by Pugin here, pp. 2, 4, 55-58.

laudatory, florid prose, the Brandons are passionate devotees of the 'art' of the carpenter. They effuse over the 'taste and skill exhibited' in the design of the roofs, determining that, 'there is no portion of a building ... requiring more skill in its construction, or that is more susceptible to ornament and decoration', the product of the, 'matchless skill of the carpenter's art.'[11] The Brandons display a jingoistic pride in these carpentered achievements: 'whatever superiority they may claim, there is scarcely a timber church or other building on the Continent of Europe which can boast of such specimens of timber roofs as are to be met with in almost every county of our own land.'[12] There is no record that the Brandons travelled extensively through Europe scrutinising continental carpentry, but their nationalistic observation holds true. Especially in its development of the display roof, English medieval carpentry was remarkably distinct.[13]

Such art was not merely the product of consummate but disinterested craftsmanship. As the Brandons make plain, it was the divinely-inspired fruit of devotion, an architectonic expression of faith and piety, its anonymous patrons and artificers - the common people of the parish - dreaming 'not of a perishable home who thus could build', so much so, that one may 'trace in every work of their hands a refined piety and a fervent faith, which delights us the more we unfold the pages of antiquity and learn to decipher a hidden lore which is to be read within the walls of every ancient Church.'[14] Furthermore, if, for the builder, the structure and symbolism of these roofs were an expression of devotion, they were meant to evoke the same in the faithful below: 'the eye was led upward to the arched roof and the spirit followed in prayer,

---

[11] Brandon, 2.

[12] Brandon, 22

[13] On the distinctiveness of English medieval carpentry see William Harrison, *The Description of England*, 1577, ed. G. Edelen (New York / Washington: Dover Publications / Folger Shakespeare Library, 1994), 199, 266, 26; R. W. Brunskill, *Timber Building in Britain* (New Haven and London: Yale University Press, 2nd ed., 2007), 13, 14; Nigel Saul, *A Companion to Medieval England 1066-1485* (Stroud: Tempus, 2005), 134. Any perusal of books on continental carpentry confirm the uniqueness of English display carpentry: H. Janse, *Houten Kappen in Nederland 1000-1940* (Delft: Delftse Universitaire Pers, 1989); G. Binding, *Das Dachwerk auf Kirchen im Deutschen Sprachraum vom Mittelalter bis Zum* ... (Deutscher Kunstverlag, 1991); Frédéric Épaud, *De la Charpente Romane à la Charpente Gothique en Normandie: l'évolution des techniques et des structures de charpenterie du XIIe au XIIIe siècles* (Caen: Publications du CRAHM, 2007).

[14] Brandon, 3.

everything conspired, "to rouse the heart and lead the will / By a bright ladder to the world above."' To the observer of sufficient sensibility, these roofs would 'realize all he can conceive of beauty and sublimity'.[15] For the Brandons, therefore, just as it was intended that the medieval hovel-dwelling disciple should have his eyes raised aloft in awe and mind elevated on entering the divine grandeur of a medieval cathedral, so the more modest dimensions of the parish church should have a corresponding impact, and impart 'holy impulse from ... solemn magnificence.'[16] And this discussion of beauty and sublimity should remind that these roofs were intended, not merely as shelter from the elements, but to be seen. Although some roofs of the period were of rough carpentry, intended to be ceiled and concealed by panelling, these were 'open roofs', decorative objects, designed to evoke feelings of wonder and stimulate acts of devotion. The Brandons' estimation of these roofs as products, and evokers, of devotion is important and will be returned to when East Anglian hammer-beams are discussed later in Chapter 8 of this thesis.

Of all this evocative carpentry, the Brandons were clearly enthusiasts for the hammer-beam roof, as, although they divide timber roofs into four main types, the hammer-beam receives the longest treatment. Of eighteen pages devoted to typology, six are reserved for hammer-beams (over twice the length of the studies of trussed rafter and collar-braced roofs). In the mid-nineteenth century the earliest example was believed to be Westminster Hall, then dated to 1399.[17] Yet of this 'magnificent specimen', of such 'boldness and sublimity of design', and notwithstanding the inability to accurately date other buildings, their judgement is shrewd and prophetic: 'We cannot bring ourselves to believe that so exquisite an example ... could be the earliest roof of the kind executed.'[18]

---

[15] Brandon, 4.
[16] Brandon, 5. Pugin writes: 'a man who builds a church draws down a blessing on himself both for this life and that of the world to come, and likewise imparts under God the means of every blessing to his fellow creatures.' 42.
[17] Brandon, 20.
[18] Brandon, 20, 21.

On the aesthetic impetus of hammer-beam construction, their analysis is uncomplicated if lapsing into the poetic: 'They saw that their favourite form, the Pointed arch, could be safely employed in their roofs without the accompaniment of the unsightly tie-beam, and at once they carried to a perfection hitherto unattained, those splendid roofs, the pride of our oak-bearing land.'[19] So, as later commentators have observed, hammer-beam construction allowed Gothic builders to incorporate their favoured motifs – the pointed arch and the trefoil – and thereby opened up a vista through the roof space.[20]

Turning to the technical genesis of the hammer-beam roof, the Brandons' analysis is concise, perceptive and convincing. The development of the hammer-beam roof depended entirely upon the simple expedient of elongating the sole-piece, the short timber that, along with the ashlar post, served to triangulate the foot of the common rafter and thus resist spreading.[21] This method provides 'an excellent hold, and obviated in great measure the danger of the roof spreading', and they continued that 'this [sole piece - ashlar post – rafter foot combination] in our opinion ... gave the idea of the beautiful hammer-beam roofs (see Glossary).[22] The then contemporary theory that the hammer-beam roof was essentially an interrupted tie-beam roof, as though the central section of the tie beam had been cut away, is dismissed in two paragraphs.[23] The commonly held view among many modern-day scholars that the hammer-beam roof is

---

Not all critics were admirers of the hammer-beam roof in the mid-nineteenth century, notwithstanding the heyday of Gothic Revival: 'In England All judicious timber roofing ceased, in buildings of pretension, about 1400, and gave place to the extravaganzas alluded to above, of which, Westminster Hall (begun 1393) was the first and largest in scale, and the Middle Temple Hall probably the most senseless and wasteful for its size.' – Peter Barlow in Tredgold & Barlow, *Elementary Principles of Carpentry* (London: John Weale, 4th ed., 1853), 93, 94.

[19] Brandon, 22.

[20] Brandon, 21.

[21] Brandon, 22.

[22] Brandon, 18. This explanation of hammer-beam development has been in turn propagated and dismissed by later writers. See J. T. Smith 'The Reliability of Typological Dating of Medieval English Roofs', in R. Berger (ed.), *Scientific Methods in Medieval Archaeology* (Berkeley Ca.: University of California press, 1970), 255; Lynn Courtenay, 'Westminster Hall and its Fourteenth-century Sources', *Journal of the Society of Architectural Historians*, Vol. 43, No. 4 (Dec. 1984), 296. I will consider the theory in more detail later in the thesis.

[23] Brandon, 20, 21.

derived from the structure of the medieval aisled hall - an aisled hall *sans* aisle posts in the quest for unobstructed floor space - was not part of the Brandons' consciousness.[24]

In general, and understandable given the period, their grasp of forces in roof structures is rudimentary and intuitive. Indeed, their statement, 'the [hammer-beam] construction completely obviates all danger of the roof opening at its base', must be viewed as a one of hubristic boldness, as the later insertion of metal tie-rods and even timber tie beams in some roofs demonstrates.[25] During the fourteenth-century construction of Westminster Hall, Hugh Herland worked closely with the King's Mason Henry Yevele to ensure that the masonry was strengthened to contain the lateral stresses and weight of the new roof.[26]

With typology the Brandons are on surer, indeed innovative, ground. They divide hammer-beam construction into four distinct categories, 'the most usual varieties', within which, as their plates show, are an infinite number of subtle variations (Figs. 3.1-3.4).[27] In italics are the modern terms for their sometimes imprecise terminology:

> 1: 'those with hammer-beams, collars and struts [*hammer posts*], connected together with curved braces' [Little Welnetham Church, Suffolk, their plate 15]
>
> 2. 'those in which the collar beam is omitted and the curved braces are carried up almost to the ridge and framed at the apex of the arch into a wedge-shaped strut [*king pendant*] into which the principals are also tenoned.' [Trunch Church, Norfolk, their plates 18, 19]

---

[24] Richard Harris, *Discovering Timber-Framed Buildings* (Princes Risborough, Bucks: Shire Publications Ltd., 3rd ed., 2006), 18, 19.

[25] Brandon, 22. See also their comments on the structural performance of hammer-beams on page 23. Two of many examples of hammer-beam roofs with later-inserted iron tie-rods: Thornham Church, Norfolk; Bacton Church, Suffolk. Ringshall Church, Suffolk, has had timber tie beams inserted.
Discussions of structural theory and, attempts to theorize and understand the forces in roof geometry started in the late 18th c. with Peter Nicholson, 1797, *The Carpenter's and Joiner's Assistant,* and into the 19th c. with Barlow: *An Essay on the Strength of Timber* (1817); see David T. Yeomans, *The Trussed Roof: Its History and Development* (Aldershot: Scholar Press, 1992), 164, 165.

[26] *HKW*, 529; Nicola Coldstream, *Medieval Architecture (*Oxford: OUP, 2002), 57.

[27] Brandon, 23, 24.

3. 'having collars but no struts'[*no struts: curved timbers rather than hammer posts*]. [Capel St Mary Church, Suffolk, their plates 16, 17]

4. 'hammer-beam roofs without either collars or struts [*hammer posts*]. [Palgrave Church, Suffolk, their plates 21, 22]

The Brandons, here, ignore the longitudinal sections of these roofs. Only the principal transverse frames, rather than any distinct intermediate framing typical of many roofs, attract their analysis. Further, it must be acknowledged that the list, consisting of only four types is arbitrary, making no cognisance of the subtle variability of features that meander through typological boundaries. Nonetheless, the brothers display a degree of insight in these classifications. Their four categories correspond well with those of later scholars, for example, R. A. Cordingley (1961).[28] Although Cordingley proposed nine different forms of the hammer-beam, four of his types (he names them differently) mirror those of the Brandons.[29]

Problems, nevertheless, can be found in this typology. Roofs containing canted arcuate timbers rising from the hammer beam, in lieu of braced, straight hammer posts, are given their own category (category 3). Such carpentry is typical of many, particularly Suffolk, hammer-beam roofs. By assigning a discrete category to these roofs, however, the Brandons deny the strutting function of the arcuate timbers. Yet, as argued in Chapter 2, the structural function of these components differs little from arch-braced hammer posts of this thesis. Such arcuate construction perhaps merits an autonomous type, but, if so, it is strictly a *formal* type rather than a *structural* type. In my typology of structure in Chapter 8, therefore, I combine the Brandon categories 1 and 3. A further problem is encountered with their category 4; indeed, the very existence of this category is questionable. The Brandons state that this type of roof has no collar, yet the example they supply, Palgrave, patently does have a collar, albeit placed high. Perhaps its severely cranked form, resembling two arch braces jointed in some manner, misled the

---

[28] 'British Historical Roof-Types and Their Members: A Classification', *Transactions of the Ancient Monuments Society* IX (London: The National Monuments Society, 1961), pp. 73-118

[29] Cordingley, 89, 95.

brothers.[30] Yet this component, as any collar, consists of a single transverse timber. Palgrave, then, surely belongs in their category 3. Nevertheless, perhaps demonstrating the far-reaching influence of the Brandons' *Open Roofs*, even some twentieth-century writers continued to distinguish Palgrave as a distinct roof-type.[31] A final and major criticism of their typology is that it does not include the most the most common type hammer-beam roof found in Suffolk: the arch-braced collar with king post/strut (see Glossary, Fig. A). Virtually all Suffolk Church hammer-beams are of this type, and most double hammer-beams have this construction. This is a serious omission which gives a false impression of East Anglian hammer-beam carpentry. I have provided an amended and less ambiguous typology in Chapter 8 of this thesis.

Notably, with these divisions the Brandons show themselves to be interested in only rather refined versions of the hammer-beam roof. The roofs discussed and depicted in their plates feature heavily moulded timbers, arch braces, arched hammer posts, tracery-filled spandrels, carved cornices, and paint. Plainer forms are not countenanced. The Chapel of St Thomas of Canterbury Wymondham, Norfolk (now an arts centre), is of that simpler form (Fig. 3.5).[32] Skeletal, unadorned by the flesh of heavy mouldings and traceried spandrels, the arch braces of this roof create a clear void between post and beam, and each timber stands starkly defined and boasts its function. One senses this is a carpenter's roof, rather than a patron's. And yet such roofs did not stir the interest of the Brandons. Perhaps too bucolic, too redolent of the great barns, they were not fit to 'rouse the heart and lead the will / By a bright ladder to the world above.'

Yet, paradoxically, the Brandons liked structural honesty in their roofs, and ornament and refinement in the wrong place was 'deception', perhaps smacking of that pagan Classicism. Encomium is the usual response to the roof of St Peter Mancroft in

---

[30] I have discovered no other examples of such a severely cranked collar in a hammer-beam roof.

[31] See Birkin Haward, *Master Mason Hawes of Occold …* (Ipswich: Suffolk Institute of History and Archaeology, 2000), 42.

[32] Possibly late fifteenth-century - early sixteenth-century. The roof was restored in the nineteenth century, *NHLE*.

Norwich (Fig. 3.6).[33] The Chairman of the National Trust Simon Jenkins called it the 'supreme work of 15th-century carpentry, full of subtle refinement.'[34] Yet its structure troubled the Brandons. They write that while 'worthy of notice, [it] is by no means to be looked upon as an example to be followed.'[35] Perceived architectural deceit provoked this consternation. The wall posts and hammer beams at St Peter Mancroft are concealed behind sweeping ribbed constructions reminiscent of fan vaulting. Coveted by the patron of adequate means, the fan vault was the late fifteenth-century architectural object of desire. It was the height not only of contemporary taste, but of technical proficiency on the part of the mason. Yet the vaulting at St Peter Mancroft is of timber, an 'imitation of the method of building in stone', hence, architectural fraud. The true structure of the roof is hidden behind wood pretending to be stone, and the Brandons are reprobatory, if, of course, polite. This mode of construction was madness: 'deception, which of course no well-regulated mind would condescend to practise.'[36]

The Open Timber Roofs of the Middle Ages formed a late but important adjunct to the surge of interest in 'Gothic' architecture during the early and mid-nineteenth century, and must be considered in the context of the Gothic Revival propelled by A. W. N. Pugin's writings of the decade and a half prior to its publication. The Brandons chose to focus on roof carpentry, and by doing so the created an original, innovative and unique work which went on to be influential and prophetic. Its value is as an example of an architectural discipline in its nascency, and of mid nineteenth-century 'Gothic' architectural tastes among the educated. Still instructive today, its detailed architectural drawings constitute a vital reference source for the structure and ornament of early roofs. They may also serve as evidence of roofs that later became the victims of the

---

[33] Pevsner & Bill Wilson, *Norfolk* Vol. 1 (London: Penguin, 2nd ed., 1997); H. Munro Cautley, *Norfolk Churches* (Ipswich, Norman Adlard & Co., 1949), 229.
[34] *England's Thousand Best Churches* (London: Penguin, 1999), 466.
[35] Brandon, 24.
[36] Brandon, 24. Honesty to materials and construction was a rubric of mid C19 architectural theory; see Pugin, 3-9, 41; John Ruskin, 'The Lamp of Truth', Ch. 3 in *The Seven Lamps of Architecture* (New York: Dover, 1989; first pub. 1849). It became a mantra of the twentieth-century Modern Movement.

Victorian mania for restoration. Their typology, its limitations acknowledged, is also valuable for the modern student.

The Open Timber Roofs of the Middle Ages also features problems that were to bedevil the study of medieval carpentry for the next century and a half: nomenclature and dating. One can excuse the Brandons for the latter by scarce documentary evidence and the lack of any alternative in the nineteenth century; the former by the nature of a discipline in its infancy.[37] The Brandons were primarily aesthetes and Christians. For them, the 'magnificent' open timber roofs of the Middle Ages were works of art, designed to intensify the religious experience.

F. E. HOWARD (and George Ellis?): 'ON THE CONSTRUCTION OF MEDIEVAL ROOFS', 1914.[38]

The Brandons and their evident enthusiasm attracted few acolytes. For the best part of seven decades the study of medieval carpentry was limited to occasional papers delivered to the RIBA AGM and articles published in *The Ecclesiologist*.[39] Given the dearth of scholarship and interest, the architect F. E. Howard's paper is one of the most important and influential works published on the subject of medieval timber roofs. Later writers repeatedly refer to it (often without acknowledgement); his nomenclature is insightful, and much of it still valid and in use today.

Howard begins by validating his topic by stating that 'some ... are inclined to make light of this English triumph, holding that the timber roof is so inferior to the stone vault as to be almost beneath notice.'[40] He points out that a roof is always essential to a

---

[37] Both problems have only found solutions in the late twentieth-century: precision in roof taxonomy in the works of Brunskill, and N. W. Alcock et al; and ascribing age by the introduction of tree-ring dating (dendrochronology). The Brandons made no attempt to accurately date their examples anyway, a fact that is stimulus for further research.

[38] *Archaeological Journal,* Vol. 71 (1914), pp. 293-352.

[39] For example, see George Edmund Street, 'On English Woodwork in the Thirteenth and Fourteenth Centuries', *Royal Institute of British Architects, Transactions,* 1st series, Vol. 14, 1864/1865, pp. 85-108; 'Church Roofing' *The Ecclesiologist 3*, nos. 31-32, May 1844; and Thomas Moseley, 'Open Roofs', *British Critic 29*, April, 1841.

[40] Howard, 293.

building, while the much admired and analysed vaults are not, concluding that, 'those builders who turned the necessary roof into a thing of beauty achieved a greater triumph than those who, despairing of ever bringing it into harmony with the rest of the structure, concealed it behind a vault of masonry'. Howard continues by acknowledging the achievement and singularity of the Brandons' *Open Timber Roofs* of six decades earlier, but he contends the work to be limited and lacking in intellectual rigour. Thus, Howard makes plain the threefold purpose behind his paper: (i) 'to supplement the Brandon's previous examples … not neglecting the plainer roofs', (ii) 'to set out a system of classification based upon primary constructional principles', and (iii) to investigate 'the purpose of the various members of roofs and the strains which they undergo.'[41] Thus, in a ground-breaking approach, Howard extends the work of the Brandons by analysing construction, and considering that construction in the context of structural theory. Interestingly, exposition of the chronological development of timber roofs is omitted from these stated aims, although Howard does go on to make an attempt, albeit with limited success.

Structure, Strain and Typology

For the medieval carpenter, lateral thrust was an inevitable and perennial problem. As Howard makes clear, the craftsman had two ways of approaching it: rely on the mason by building walls of such mass that the roof had no possibility of spreading due to their immovability; or construct the roof in such a manner that its structure resists spreading. Put another way, either the masonry or the carpentry has to control lateral thrust. The latter approach is exemplified most overtly by the tie-beam roof, and to a lesser extent, the hammer-beam roof. With regard to the former approach, Howard stresses the role of medieval masonry, normally of massive section, in dealing with thrust, observing that 'such walls are naturally capable of resisting a great deal of overturning pressure.'[42] Here, one may be critical of Howard. He fails to take into account the properties of medieval

[41] Howard, 294.
[42] Howard, 295.

lime-based mortar, assuming a modern mortar, rigid and inflexible in nature, which would indeed render the wall a single monolithic slab resistant to overturning. Rather, lime-based mortars have extremely long setting times and remain plastic for most of their lives.[43] I have seen countless examples of walls where the masonry has been increasingly pushed out of plumb in relation to its proximity to the top of the wall and the thrust of the roof.[44] A further point to keep in mind with regard to hammer-beam roofs is that many of the East Anglian examples were built atop high, relatively thin un-buttressed clerestory walls, often constructed of flint rubble. The thrust-resisting capacity of this type of masonry must be limited. Nevertheless, when writing of 'roofs and the strains which they undergo', Howard is perceptive and accurate. He recognises the important development of the triangulated rafter foot in increasing the stability of a roof, as 'thrust is brought down in a more vertical direction.'[45] Howard then proceeds with his illustrated typology – then the most detailed and extensive yet published.

An important notandum is that Howard throughout his paper is concerned with the *action* of the roof. As he states, '*The thrust or the absence of thrust is the all-important element in roof-construction*' (emphatic italics his), and from this statement he develops a broad tripartite typology based on the thrusting action of the roof: (i) Roofs with no thrust (For Howard, mainly 'beam' roofs), (ii) thrusting roofs, and (iii) trussed roofs (this last group could be in category 'i', since 'trussed roofs', as the name implies, exert no thrust).[46] Percipient though the other categories are, for the purposes of this study of hammer-beam roofs, only category 'ii' is of interest.

---

[43] N. Davey, *A History of Building Materials* (London: Phoenix House, 1961), 98, 103.

[44] To give just three examples, the Great Hall at Eltham Palace; Idlicote Church, Warwickshire, nave; Ringshall Church, Suffolk, where the single-framed common rafter roof had pushed the walls out of the perpendicular by around 10 inches. Extreme remedial measures were taken in the C15 and tie beams were inserted *below* the wall-plate and carried through the wall, pinned by huge oak pegs; see H. M. Cautley, *Suffolk Churches …*, (Woodbridge: The Boydell Press, 5th ed., 1982) 91, 261.

[45] Howard, 316.

[46] Howard, 302-4.

Hammer-Beam Roofs: Origin

Howard's comments on the aesthetic of a hammer-beam roof are brief, limited to the Brandon-derived comment that the hammer-beam roof usually provides the ubiquitous Gothic motif of the trefoil.[47] Howard is more concerned with the type's structural genesis, and he proposes two developmental nodes. Firstly, in a restatement of the Brandon view, he contends that the hammer-beam roof is derived from the triangulated configuration of the common rafter foot: 'When the sole piece projects from the wall, it is called a hammer beam ... the most elementary form of the hammer-beam roof ... The invention of the sole-piece ... made the discovery of the use of the hammer-beam inevitable' (see Figs 2.8 & 2.9). [48] While this view prevailed well into the late twentieth century, it has been dismissed by later scholars, most notably the specialist in vernacular architecture J. T. Smith, and in the early twenty-first century the contention was currently out of favour. [49] Later in this thesis, however, I will re-evaluate the Brandon / Howard view, and argue that the rafter foot did indeed influence the structure of fifteenth-century hammer-beams.

Howard's second suggestion for the structural source of the hammer-beam roof seems more novel: the hammer-beam originated in the carpentry of the arch-braced collar roof (Fig. 2.15).[50] For Howard, this roof-type developed as follows. In their attempts to contain lateral thrust, carpenters devised the wall post, and then arch-braced this innovative timber to a principal rafter.[51] This contignation moved the thrust to a lower, more stable point on the masonry. The addition of an upper curved brace, framed from the principal to a collar, produced the arch-braced roof, a popular form of display carpentry during the fourteenth and especially the fifteenth centuries. However, this

[47] Howard, 320.
[48] Howard, 318.
[49] Courtenay, (1984), 296, nt. 11. See also Courtenay, 'Where Roof meets Wall: Structural Innovations and Hammer-beam Antecedents', in Pamela O. Long ed., *Science and Technology in Medieval Society* (New York: The New York Academy of Sciences, 1985), 90. J. T Smith (1970), 254-6, nt. 30.
[50] Howard, 318-20.
[51] Wall posts can be seen in germinative form at Bradford on Avon Tithe Barn, Wiltshire, 1334-79d.

form of construction has disadvantages, though as Howard argues, disadvantages which proved to be serendipitous for the development of the hammer-beam.

The difficulty is this: to be most effective, ideally the wall post needs to be as long as possible. But this would mean that the curved brace would also have to be proportionately longer, and more importantly, assuming the carpenter wanted to maintain closed spandrels, wider. Long and narrow curved timbers might be readily available; short, wide timbers equally so; but such long *and* wide, arcuate timbers are difficult to obtain, and just as importantly to a carpenter, to convert. Further, with a later-Middle Ages' penchant for low-pitched roofs, and concomitantly wider braces, the problem would be exacerbated.

Howard proposes that the 'remedy' to what was essentially a timber supply problem was an extended sole piece, this horizontal timber dividing the lower brace into two sections. Projecting from the wall plate, braced from below and in turn supporting a brace, this timber now became the hammer beam. Howard argues that this modified framing is even stronger than before, but this is arguable.

To illustrate his developmental progression, Howard adduces three illustrated examples (his Fig. 20; my Fig. 3.7). In Edington Church, Wiltshire, an arch-braced frame is placed against the gable of a low-pitched roof (Fig. 3.8). In what might be dubbed a 'scarfed arch-brace', the arch-brace is formed of two timbers, jointed at around the midpoint of the haunch. It is unclear how the carpenter conceived and cut this joint, but one thing is sure: it is shoddy design. One imagines he perhaps cut a long 'chase' mortice, into the two main timbers, and then fitted a loose tenon, but such any joint in this predominately end-grain to end-grain joinery would be inherently weak. Under any tension or leverage the pegs would tend to shear out of the shoulders. Further, chopping accurate mortices into end-grain fibres is difficult and time-consuming. An extended sole piece, as Howard suggests, would divide the joint and obviate these problems. Hence, the next example Howard provides is that of St Michael-at-Plea in Norwich, where the joint is shown divided in just such a fashion. The final example, St Giles, Norwich, provides the culmination of Howard's progression, a fully formed hammer-beam roof of arch braces of solid spandrels.

Howard's position, then, is that the hammer-beam roof developed from the arch-braced roof, a contention he peremptorily repeats three years later in *Early Church Woodwork*.[52] As a suggestion of genesis and development, Howard's proposal has an apparent logic, and cannot be summarily dismissed. It gained currency among twentieth-century writers, most notably David Yeomans.[53] When tested, however, like the Edington joint, cracks begin to appear.

As an illustration of what *may* have happened, Howard's three examples are useful, but they are not evidence of any *actual* progression. The carpentry at Edington church, which Howard claims as late fourteenth-century, is of uncertain date.[54] Indeed, its low-pitched roof connotes fifteenth-century construction. If so, Edington would be of the same period of Howard's 'later' hammer-beam roofs in Norwich, and indeed, later than the mature example, St Giles, which dates from the early fifteenth century.[55] With regard to St Michael at Plea, the roof is not flat-pitched as at Edington, and the arch brace is relatively short and narrow, having a small spandrel.[56] It seems unlikely that the carpenter inserted a hammer beam merely because he could not locate timbers of adequate section.

The built evidence, therefore, for such a progression does not exist, but is Howard's developmental suggestion theoretically likely? Howard's argument assumes a demand for interrupted arch-brace construction. This assumption is itself based on three assumptions: (i) widespread low-pitched roofs in the late fourteenth century creating a demand for wide-spandrel arch-braces, (ii) the reluctance of carpenters to use alternative means to fill the spandrel, and (iii) a scarcity of long, arched timbers. Firstly (i), the

---

[52] P. 104.

[53] David Yeomans, 'Historic Development of Timber Structures', in Sunley and Bedding (eds.) *Timber in Construction* (London: Batsford / Trada, 1985), 69; *How Structures Work* … (Oxford: Wiley-Blackwell, 2009), 182.

[54] Neither *NHLE* nor Pevsner accurately date the Edington roof.

[55] See Appendix III for my comments on the date of St Giles, Norwich.

[56] *NHLE* date St Michael at Plea to 'C15.'

ubiquity of low-pitched roofs in the fifteenth century is something of a fallacy. Most fifteenth-century church roofs in East Anglia have a pitch of around 40 degrees, some greater. With such a pitch, the wide spandrel is less of a problem to be overcome. Secondly (ii), carpenters readily used alternative means to create a solid spandrel, by framing in an infill timber to plug the gap. Tunstead Church, Norfolk (Fig. 3.9), and Bardwell, Suffolk are just two of many examples of this technique. Alternatively, and more commonly, carpenters viewed the broad spandrel as an opportunity for ornament, and filled the spandrel with tracery (Fig. 3.10). Finally (iii), regarding the possible scarcity of suitable arcuate timbers: the late fourteenth and the fifteenth century was the crucial period of development and establishment of the arch-braced roof, and carpenters happily continued constructing many grand examples without needing to divide the arch braces with a horizontal timber.[57] The carpenter of the magnificent arch-braced roof in the hall of the Hospital of St Cross, Winchester (1444 ± 7d), had no difficulty finding suitable timbers for his structure, indeed, wall-post and lower arch braces are fashioned from single timbers (Fig. 3.11). In similar vein, some East Anglian carpenters, rather than divide the brace between hammer beam and collar, as was convenient and customary practice, elected to use one long curved timber in this position (Fig. 3.12; also Fig. A in Glossary).[58] In other structures, any resulting open spandrels were accepted, or plugged with infill pieces or adorned with tracery.[59]

Hammer-beam and arch-braced roofs continued to be constructed in parallel throughout the fifteenth century. To include hammer beams, whether short or long, with open or closed spandrels, was a conscious aesthetic decision, rather than a Hobson's choice forced on the carpenter because of timber supply problems triggered by new trends in roof pitch. Patrons could *choose* between an arch-braced and a hammer-beam

[57] To give two fourteenth-century examples: the hall of Daneway House, Bisley, Sapperton, Gloucestershire, 1315d; The Guesten Hall Roof, *c*. 1320, formerly part of the Worcester Cathedral complex, now relocated to the Avoncroft Museum, Bromsgrove. Fifteenth-century examples are numerous.

[58] Suffolk examples of this practice are in churches at Tuddeham St Martin, Wingfield, and Otley.

[59] For example: the Great Hall, Bishop's Palace, Ely, the Guesten Hall, the Guard Room, Lambeth Palace.

roof, sometimes selecting both – usually an arch-braced for the chancel and a hammer-beam for the nave.[60]

Even the germ of Howard's proposal, that the unsound construction at Edington was widespread, forcing carpenters to seek a solution to a common problem, is unconvincing. Edington is the only example Howard supplies, and it is the only example I have yet discovered, of a scarfed arch-brace. The construction is so flawed, that it is unlikely to have been a configuration the late fourteenth-century carpenter would have been familiar with. Any competent carpenter would have eschewed such slipshod construction, and probably the only reason the carpenter employed it at Edington is that the cross-frame, immediately adjacent to a gable wall, is performing little, if any, structural duty. One suspects this novel framing was framed into this tie-beam roof with more formal motives in mind: that of terminating the nave with a pleasing Gothic arch.

To précis the above comments on Howard's proposal of hammer-beam origin: Howard implies that the 'interrupted arch-brace' was a solution to a structural problem created by demands of form, and a dearth of suitable timbers to fulfil those demands. The evidence, however, indicates that no such structural problem existed to be solved. The explosion in hammer-beam construction in the fifteenth century, in parallel with continued arch-braced construction, denotes that the hammer-beam was a deliberate aesthetic - rather than structural - preference, a choice propelled by formal and ornamental possibilities unavailable in contemporaneous arch-braced roofs.

Hammer-beam Roof: Structure

Leaving behind Howard's suggestions for the genesis of the hammer-beam roof and returning to 'the purpose of the various members of roofs and the strains which they undergo', Howard proves himself percipient and prescient. Apropos of the hammer-beam roof he writes 'the hammer-beam [the discrete timber] is a pure cantilever, the wall plate being the fulcrum, while the rafter foot is the point of application, and the

[60] South Acre Church, Norfolk, is just one of many examples of this arrangement.

brace, carrying the rafter, is the weight.'[61] Lucid and concise, this is the earliest statement I have found in an academic paper accurately referring to the hammer beam as a cantilever which extends through the wall plate to be pinned in place by the principal.[62] Also, and confirmed by later writers, Howard observes that the hammer beam, and possibly the wall post, are the only timbers in a hammer-beam frame which are in tension, a fact key to understanding the function of a hammer-beam frame.[63] Allied to that understanding, Howard appreciates that hammer beams lacking the supporting wall post and brace, as at Mildenhall in Suffolk, are structurally useless, and function only as decoration (Fig. 3.13). Composite bracket components are key to the stability of the hammer-beam roof since they move the thrust lower down the wall, so that 'the roof cannot slide outwards without pushing off the top courses of the wall.'[64] Interestingly, Howard notes that it is *thrust* and not roof weight that the hammer-beam bracket configuration moves to a lower, more stable point on the wall, although one might be pedantic here and argue that the bracket converts vertical roof weight to diagonal thrust.

Howard is also the first scholar to use the term 'false' in the context of hammer-beam roofs. As was noted in Chapter 2, the term 'false' was to be subsequently applied to hammer-beam roofs with a variety of meanings. For Howard, it simply meant the upper tier of hammer beams in a double hammer-beam roof which are so framed as to have no structural function, thus 'projecting uselessly into empty air.'[65] That, however, is not to say that all double hammer-beams are 'false.' Howard contends that, provided they are of sound construction following the principle of bracket construction, 'the system might be extended indefinitely, and triple and quadruple hammer-beam roofs are within the bounds of possibility.' No triple or quadruple hammer-beam roofs are known to exist.

---

[61] Howard, 318.
[62] Thomas Morris groped his prolix way along the same path, but referred to the hammer beam as forming part of a 'jib', 94, 95.
[63] Howard, 300.
[64] Howard, 318 & nt. Also 317.
[65] Howard, 320 & his Fig. 22.

Finally on the theme of structure, Howard has a brief comment about the roof at Westminster Hall. This structure he sees as the application of a 'double system of arch-braces', to create a frame of enormous strength, and he regards a major component of that double system, the great arched rib of the Westminster roof, as of prime structural importance.[66] He strays into supposition here (the function of the great rib will be discussed extensively later in this thesis), and this is a lackadaisical paragraph untypical of the paper. He includes the roof of Eltham Palace as an example of a 'double system of arch-braces', which it self-evidently is not. 'Enormous strength' is not one of the attributes of the Eltham roof, which throughout its life has endured dilapidation and extensive renovation due to its inept design.[67]

F. E. Howard was midwife to a nascent discipline aspiring to academic respectability, and *On the Construction of Medieval Roofs* is a thoughtfully structured paper written with admirable clarity and concision. In such an esoteric field, later writers, such as J. T. Smith, could have learned from Howard's style, much to the benefit of the reader and the advancement of the discipline. The paper is further enriched by Howard's own simple, but elucidatory drawings. Here, finally, was a clear typology based on the study of a range of roofs. Howard's comments on the structural performance of various roof-types are, in the main, percipient and prescient. Errors are mainly the result of the age in which he is writing.

Praise cannot be unalloyed, however. While acknowledging his debt to the Brandons, Howard, perhaps, does not accord another writer similar respect. His comments on the structural function of the hammer-beam frame, his talk of 'fulcrums', distributions of 'thrust', and 'cantilevers', can all be found in a craftsman's manual: George Ellis's *Modern Practical Carpentry* written just a few years earlier in 1906.[68] As well as a consummate craftsman, Ellis was a shrewd observer. Indeed, the analytical and

---

[66] Howard, 320, 332.
[67] The Eltham roof is discussed in Chapter 8 of this thesis.
[68] Ellis, (London: Batsford, 1st ed., 1906), 76-77, 97.

expository nature of much of the book transcends that of a mere trade manual. Thus, the germ of Howard's seemingly original suggestion, that the hammer-beam originated in a divided arch brace, is also found in the Ellis's work. Is this an example on Howard's part of condescension? An example of the traditional and patronising view of the craftsman - a banausic follower of orders, incapable of creativity or original thought – manifesting itself in Howard's citatory omission? Perhaps a mere carpenter was deemed unfit to be referenced and respected in a work of academic ambition authored by a member of the professions. Indeed, Howard was to develop a keen interest and a high degree of expertise in the design and construction of ancient woodwork, particularly of an ecclesiastical nature. Three years later he produced (with F. H. Crossley) the magisterial *English Church Woodwork: A Study in Craftsmanship during the Mediaeval Period,* including an admirable chapter on roof carpentry which amplified his 1914 paper. Is it likely that Howard, an architect with a fascination for all things woodwork, would not have consulted the premier carpenters' manual of his day, a work that would go into three editions and numerous reprints? The question must be left open, as one cannot be certain that Howard consulted Ellis's manual. But the suspicion leaves this seminal paper somewhat tainted.

GEOFFREY WEBB, *ARCHITECTURE IN BRITAIN: THE MIDDLE AGES* (1956)

For over forty years the study of medieval roof carpentry became the province of the rare descriptive survey. Examples of the type are found in Howard and F. H. Crossley's *English Church Woodwork* (1917) H. Cescinsky and E. R. Gribble's, *Early English Furniture and Woodwork* (1922), and Crossley's, *Timber Building in England,* (1951). Academia largely ignored the topic. In the face of such apathy, it is refreshing to find that in *Architecture in Britain: The Middle Ages* (1956), Geoffrey Webb, the Slade

Professor of Fine Art, devotes eight pages to 'the great achievements of monumental timber construction'.[69]

This is not another panegyric to the craft of the carpenter in the style of the earlier survey writers. Webb is less effusive and more objective, and when his thoughts turn to tracing structural development, he is also less dogmatic. The eight pages are peppered with phrases such as: 'little or no evidence', 'seems extremely likely', 'we are left with inference', 'suggests', 'is said to'.[70] The following sentence is particularly telling: 'It cannot, however, be too clearly stated that we have little or no real evidence on this subject and all is inference and speculation.'[71] This is a candid writer who admits the lacunae in the discipline in the mid-twentieth century, and who repeatedly laments a major reason why: the lack of reliable dating methods.[72] Such candour, however, does not extend to acknowledgment of the other major cause: academic indifference.

Webb allocates a substantial proportion of his discussion to the hammer-beam roof, which he describes as 'the most striking development ... in fourteenth-century carpentry ... capable of extreme elaboration'.[73] Significantly, he offers the Pilgrim's Hall in Winchester as the earliest example, 'said to be' of the first half of the fourteenth century, a suggestion that conflicts with the theory advanced by some contemporary and recent observers, that of East Anglia as the cradle of the hammer-beam.[74] Webb offers no further information, however, on this pivotal structure in the development of the hammer-beam roof, and it was left to later scholars to confirm Webb's intuitions. A descriptive passage follows on 'the most splendid example of late medieval timber-work':

---

[69] 187; edition cited here is, Harmondsworth: Penguin, 2nd ed., 1965.
[70] Webb, 185-192.
[71] Webb, 187.
[72] Webb, 187, 189.
[73] Webb, 189.
[74] Crossley, 139. See also the information on a model of a hammer-beam in the V & A's collection, which describes it as 'developed by Suffolk carpenters.' Victoria and Albert Museum: <http://collections.vam.ac.uk/>, accessed 10/10/2012.
Nathaniel Lloyd suggested Pilgrims' Hall belonged to early on the C14 in *History of the English House* (London: Architectural Press, 1931), p. 34.

the hammer-beam roof at Westminster Hall, for which Webb gives a start date of 1392. [75] Of its position in the chronology of hammer-beam development, Webb is at one with the Brandons, and denies Howard and Crossley's assertion that Westminster was the archetype of the form, averring that it is 'frankly incredible that that such an elaborately developed example should be the origin of the type'.[76]

Webb maintains such acuity as he concludes his discussion of hammer-beams with two novel propositions.[77] The first is that the decorative potential of hammer-beams may have prolonged the life of the high-pitched roof in the face of a vogue, both for reasons fashionable and practical, for low-pitched roofs during the fifteenth and sixteenth centuries. Secondly, without exposition, he introduces the idea that the configuration of the hammer-beam roof, presumably its interplay of beams and posts, its vista of receding cusped arches, and its adornment – ranks of angels - could act as a *repoissoir*. Is it possible that these structural components are arranged to direct the gaze, to concentrate the vision, to accentuate the space above and beyond, towards the sanctuary and its altar? This would demand a high degree of compositional sophistication on behalf of patron and builder. Neither of these ideas is developed, and later in this thesis I will attempt to rectify this omission.

Webb's contribution to the enquiry into timber buildings is a thought-provoking and honest account of the existing state of the discipline. At last, here was a writer free of casual assertions and who admitted to the 'inference and speculation' rife in the field. And yet, Webb's considered piece is no capitulation in the face of a dearth of evidence and an excuse to settle back into indifference. It stands testimony to the continued validity of the field and a plea for further research, which Webb emphasises stating 'further study of the very elusive evidence of early timber building is one of the tasks

[75] Webb, 189, 190.
[76] Howard & Crossley, 104.
[77] Webb, 109.

which is crying out for the attention of architectural historians.'[78] Inevitably, Webb captures a period when a valid field of enquiry was stagnating, not least due to a haughty academia as much as to any evidential elusion. It would be for future researchers, decades hence, to enjoy the Elysian fields of dendrochronology.

J. T. SMITH, 'MEDIEVAL ROOFS: A CLASSIFICATION', 1958.

As noted above, due to a combination of academic snootiness and sparse evidence, twentieth-century studies of medieval timber structures embody a lack of rigour which, reflective of academic indifference, led to stagnation in the field. J. T. Smith in his 1958 paper 'Medieval Roofs: A Classification' recognised this lamentable state of affairs, conceding that, in over a century, 'few have studied them [timber roofs] seriously and none from a historical standpoint.' Even the Brandons and F. E. Howard 'only incidentally and vaguely ... discuss the chronology and development of the structures they describe.'[79] Smith set out to correct this deficiency, and his paper constitutes the first attempt since F. E. Howard to apply any academic rigour to the typology and development of medieval roofs. As such it has become seminal paper, included in the bibliographies of all subsequent literature, and obligatory reading for all students entering the field.

Smith's method is one of placing structures into distinct classifications, and then examining how those structures developed within those classifications.[80] He spends over a third of the paper discussing the regional distribution of roof-types, as he believed certain roof-types were found almost exclusively in particular regions. As will be discussed later in this thesis, hammer-beams roofs have a distinct geographical grouping, but on such extraordinary distribution, Smith makes no comment. A small but crucial part of Smith's paper is his discussion of methods used by carpenters for 'clearing away

[78] Webb, 185.
[79] J. T. Smith, 'Medieval Roofs: A Classification', *Archaeological Journal*, Vol. 115, 1958, (pp. 111-149), p.111.
[80] Smith, 128.

the inconvenient arcades', of medieval halls.[81] The carpenter accomplished this radical internal restructuring, Smith argues, in three ways: by means of the raised aisle roof; by the base-cruck; and via the hammer-beam roof (Figs 3.14 & 3.15).[82] Only the final treatment need detain the student of the hammer-beam.

Only a page and a half of Smith's paper pertain to hammer-beam roofs, but these brief comments are vital for the student wishing to understand at least one branch of hammer-beam development.[83] Smith argues that the hammer-beam roof developed from aisled construction, and the earliest example he supplies to prove this contention would in subsequent literature remain the paradigm of an early hammer-beam roof: the Strangers' Hall at Winchester (now known as the Pilgrims' Hall) (Fig. 3.16). Following earlier writers, Smith proposes an early fourteenth-date for the structure, but he is more interested in structural components which, for him, are indicative of aisled ancestry: the 'strut' between hammer beam and hammer post, and the relict arcade plate / purlin.[84] The arcade plate, so intrinsic to aisled construction, is retained in the hammer-beam bays of the Pilgrims Hall, and is supported on sawn-off aisle posts now resting on hammer beams. Strangely, Smith does not mention that the hammer posts are braced longitudinally to the arcade plate – a fact which would bolster his argument - as such bracing is a common feature of aisled construction. Subsequent East Anglian hammer-beams contain no such longitudinal bracing. Thus, that the Pilgrims' Hall-type of hammer-beam construction developed from aisled construction seems self-evidently true. The fly in this neat developmental ointment is the Bishop' Kitchen at Chichester, a structure I will return to in Chapter 4 of this thesis.

Smith elaborates little more on the structure of Pilgrims' Hall, but proceeds to mention two other fourteenth-century hammer-beams: the house known as 'Tiptofts',

---

[81] Smith, 120.

[82] Interestingly, John Harvey, *Gothic England* (London: Batsford, 1947), had already concluded that the hammer-beam resolved the conflict of the large span and the desire to omit supportive posts, pp. 35-36.

[83] The comments on hammer-beam roofs are on pp. 123-124.

[84] Smith, 123; Lloyd, 34, and Harvey (1947), 51, all give an early fourteenth-century date for the structure. Webb also mentions the Pilgrim's Hall, p. 189.

Wimbish, Essex (1308±21d, Fig. 3.17), and Westminster Hall. Of similar construction to Pilgrims' Hall, Tiptofts is offered, cogently, as further evidence of hammer-beam construction as an offshoot of aisled construction. For Smith, even in the 'product of the genius of the carpenter Hugh Herland,' Westminster Hall, one can trace the palimpsest of aisled construction. Here, Herland framed three tiers of purlins, the middle of which is square-set like an arcade plate, 'a relic of its origin.'[85]

Smith concludes his notandum on hammer-beams with two errors and a stimulus. Firstly, he remarks that 'no fully adequate drawings of [Westminster Hall] exist.'[86] This statement is incorrect. Held both in the National Archives and the Parliamentary Archives are exhaustive and detailed drawings of the roof prepared by HM Office of Works in 1914 prior to the roof's repair. His second error is a technical observation regarding East-Anglian church hammer-beams. He writes that 'in general they show their descent from roofs of uniform scantling [single-framed] by the mode of the fixing of the purlins, which are clasped between a principal rafter of small section and some form of collar or arch-brace.' This too is incorrect. I have personally viewed over sixty East Anglian hammer-beam roofs (and seen photographs of many more), and I am yet to see 'clasped purlin' construction (Fig. 3.18).[87] Most are constructed with heavy principal rafters into which the purlins are tenoned. Smith's stimulus also pertains to East Anglian hammer-beams: 'they assume complex forms whose development badly needs study,' a state of affairs I hope to have gone some way to rectifying in the final chapter of this thesis.

One feels sympathy for the hapless student confronted for the first time with J. T. Smith's paper, for it is a dense and discursive text.[88] Relatively simple measures would

---

[85] Smith, 124.
[86] Smith, 124, nt. 1.
[87] *CBA*, 12B
[88] The student would perhaps be wiser to begin with Smith's 'The Reliability of Typological Dating of Medieval English Roofs' (1970), which is written with greater clarity and concision and a candid acknowledgement of the limitations of the method of dating roof structures typologically.

have aided the reader, such as if Smith had followed basic academic protocol and stated his thesis and method at the introduction, or provided sub-headings to cohere his argument. The amount of digression and desultory reasoning is staggering, but buried in all the words, valuable nuggets of analysis may be unearthed. For example, while his discussion on the strict regional distribution and development of distinct roof-types has to some extent been superseded by recent scholarship,[89] the comments on the removal of aisle posts as a key driver in the technological development of carpentry, and thus the hammer-beam, are astute and indispensable. Nonetheless, in the light of fifty years of subsequent research, the advent of dendrochronology and the consequent increase in understanding, Smith's 1958 paper is in need of updating.

LYNN T. COURTENAY, 'WHERE ROOF MEETS WALL: STRUCTURAL INNOVATIONS AND HAMMER-BEAM ANTECEDENTS', 1985.[90]

Lynn Courtenay's 1985 foray into the analysis of medieval timber roofs – the field was to form the core of her writing over the next two decades – is an examination of how medieval carpenters dealt with problems of establishing longitudinal and lateral stability in roof structures of ever increasing scale. The solutions they developed, Courtenay proposes, were the structural seeds from which the hammer-beam roof grew.

Any discussion of hammer-beam roofs ought, perhaps, to contain a definition of its essential nature, and this is how Courtenay begins. In many expositions, scholars focus on the relationship between the hammer beam, hammer post and the arcade plate

---

[89] Bob Meeson, 'Structural Trends in English Medieval Building, New Insights from Dendrochronology', *VA* 43 (2012), 58-75. Richard Harris, Lecture: 'The Fruits of Dendrochronology: New Insights Into Roof Carpentry In England, Germany And France', *First Conference of the Construction History Society* (Cambridge: April 2014).
[90] In Pamela O. Long (ed.), *Science and Technology in Medieval Society* (New York: The New York Academy of Sciences, 1985), pp. 89-124. This paper is also in David Yeomans (ed.), *The Development of Timber as a Structural Material* (Aldershot: Ashgate,1999). It can also be found through an online search.
I am grateful to David Yeomans for reading a draft of this section. Dr Yeomans does not necessarily agree with all my conclusions.

or rafter that these go on to support.[91] Courtenay, however, includes the wall post — diagonal arch brace — hammer beam arrangement as also determinate of the hammer-beam frame. Without this crucial feature, essentially a bracket, a hammer-beam truss of any significant size and stability is unfeasible. The reason why Courtenay focuses on the importance on the bracket soon becomes apparent, as all the 'structural innovations' she goes on to examine relate to the timbers which make up this lower bracket. The innovations she discusses date mainly from the twelfth and thirteenth centuries, and belong to the Low Countries and northern France. It should also be noted that the innovations, unlike the later British hammer-beams, belong mainly to closed roof structures – carpentry that was designed not to be seen – and were constructed to surmount masonry, not timber-framed, walls.

A perennial problem that carpenters have had to confront throughout the centuries is that of lateral thrust – the roof's tendency to spread. Initially, as Courtenay explains, carpenters experimented with tie beams and increasing the pitch of the roof in order to deal with lateral thrust.[92] The extensive use of tie beams in large buildings is, however, intrinsically problematic. Timbers of a suitable length and girth, usually dimensionally increasing in proportion to the span, have to be sourced, converted, transported and erected.[93] This was economically undesirable and, as the Middle Ages progressed and clients especially in England desired spacious and grand open roofs, aesthetically passé. Interestingly, Courtenay makes another point relating to economy:

---

[91] For Anthony Emery, the hammer post, the hammer beam and the square-set purlin are the 'basic combination' of the hammer-beam roof. Emery does not make a distinction between 'true' and 'false' hammer-beams, *Dartington Hall* (Oxford: The Clarendon Press, 1970), 237, and 237-244 *passim*. Also J. T. Smith (1958), 123.

[92] Courtenay, 93. As anyone who as ever leaned a ladder against a wall to perform some domestic task will know, the more vertical the ladder, the less tendency it has to slip.

[93] F. W. B. Charles, *The Conservation of Timber Buildings* (Shaftsbury: Donhead, 1995), 47-49. In large scale French medieval roofs, carpenters developed 'hanger' pendant king-posts which expedited the use of tie beams of relatively light scantling. I will return to this topic later.

in rib-vaulted roofs the masonry walls would have to be raised in order for the tie beams to clear the extrados of the vault.[94]

Increasing the pitch of the roof, however, creates other problems related to stability. Lateral forces may be diminished, but, according to Courtenay, longitudinal forces augment.[95] This is a reasonable assessment, and it may be helpful in this context to think of the rafters as levers and their feet as the fulcrum. Increased truss height lengthens those levers, places extra strain on the joints at the rafter foot, and, without obviatory measures, increases the danger of the roof racking due to wind loading and / or inherent structural flaws. Further, Courtenay explains, the greater overall height of a steeply pitched roof means that a greater surface area of the roof is exposed to lateral wind forces. In stormy weather the roof can behave like a sail, with a windward and a leeward side, an effect which creates complex and difficult to control forces within the framing.[96]

A 'significant development' in medieval carpentry to control the above longitudinal forces, Courtenay argues, was the introduction of the wall plate. This component 'secure[d] the tie-beams from turning, which might result from … leverage caused by wind pressure.'[97] Courtenay's arguments here are twofold: firstly, in these huge roof frames carpenters were concerned, 'especially', with controlling longitudinal wind forces and/or racking, as opposed to lateral wind forces and lateral thrust; secondly, the wall plate was the component introduced to inhibit those longitudinal forces.[98]

---

[94] Courtenay, 93, 94. This point is discussed in more detail in Rowland J. Mainstone, *Developments in Structural Form* (Harmondsworth: Penguin, 1975), 151.

[95] Courtenay, 94.

[96] David Yeomans, *How Structures Work: Design and Behaviour from Bridges to Buildings* (Oxford: Wiley-Blackwell, 2009), 180.

[97] Courtenay, 95.

[98] Courtenay, 94. English carpenters addressed the problems of longitudinal stability in timber-framed structures with axial braces from crown post to crown plate (or 'collar' plate) in crown-post roofs (late C13 onwards), and with the aptly named 'wind brace' in principal rafter roofs, the timber usually bracing purlin and principal rafter (C14 onwards). In the choir and nave roofs of Chichester Cathedral, (*c.* 1287d), a unique English structure, carpenters experimented with bracing both from crown post to crown plate and from crown post to purlin (illustration in *EHC*, 107). In single-framed roofs, carpenters occasionally experimented

After these initial remarks on developments in roof carpentry in the early Middle Ages, Courtenay then focuses the discussion on three specific adaptions carpenters made at the base of the rafter, 'where roof meets wall'. These adaptions, she proposes, were key to hammer-beam development. They are: (i) the extended sole piece allied with the 'flying plate', (ii) the extended ashlar strut, and (iii) the saddle bracket. I will briefly consider each of these individually.

The 'extended sole piece' (Fig. 3.19) was an innovation, Courtenay writes, introduced around the second quarter of the twelfth century.[99] Here the sole piece, which normally is as long as the wall is thick, now projects beyond the vertical plane of the inner surface of the wall. With the weight of the rafter pressing on the outer end of the sole piece via the ashlar piece, the sole piece becomes a rudimentary cantilever. Lengthening the sole piece concomitantly allows the ashlar to move inwards, thus creating a larger triangle and increasing the stability of the rafter foot. The ashlar piece could be jointed as usual into the end of the sole piece or, as Courtenay illustrates, be framed into a 'flying' wall plate. In this configuration a longitudinal wall plate also moves beyond the inner plane of the wall, to be framed into the ends of cantilevered sole pieces. For Courtenay, the 'flying plate' 'locks the frames together', and is evidence again of the carpenter's concern for 'longitudinal bracing'. She also states that this flying plate 'anticipates the later development of longitudinal bracing [associated with] the purlin.'[100] These are highly original, not to say contentious suggestions, and will be returned to shortly.

---

with forms of diagonal longitudinal bracing, a practice approved in modern building construction, e.g.: Westminster Abbey, north transept, C13 (illustration in *EHC*, 112), Canon Pyon Church, C13, Herefordshire. Medieval carpenters tried other solutions to manage longitudinal wind forces, including experimenting with various forms of hipped roofs, as at the thirteenth century barns at Cressing Temple, Essex, and the east ends of many French cathedrals. In modern buildings without masonry gables often the roofs are hipped, the jack rafters serving not only as supports for the roof covering but also as longitudinal props.

[99] Courtenay, 97.

[100] Courtenay, 100.

The 'extended ashlar strut' (Figs. 3.20 & 3.21) is explained by Courtenay as follows.[101] As carpenters experimented with extending the sole piece horizontally, they were also investigating the structural possibilities of extending the ashlar vertically. Here, the sole piece remains the same length and the ashlar strut extends down the internal face of the wall to become a wall post. These timbers were usually fixed vertically to the wall and/or terminated on a corbel. An innovation of the twelfth and thirteenth centuries, Courtenay explains that it was a construction carpenters developed 'to achieve greater stability against lateral thrust,'[102] and a technique that both clips the roof frame inside the masonry, and moves the 'weight' of the roof down the wall.[103] Instead of relying on a tie beam, by incorporating such timbers in intermediate trusses, the carpenter is relying on the strength of the masonry walls to resist lateral thrust. It appears, however, that the carpenter had no faith in the ability of these timbers to manage lateral thrust alone, and in the examples Courtenay provides they occur only in roofs with frequent tie-beam trusses. A further structural point to be added is that, as illustrated in Courtenay's Figs. 14 and 15a (and my Fig. 3.20), the sole piece is of necessity framed *into* the extended ashlar. Lateral thrust, therefore, is contained by a mortice and tenon joint in tension, thus relying only on pegs to resist lateral thrust – not a trustworthy construction.[104] Courtenay provides one example of a modification to the extended ashlar, in a house in Rue de Demontry, Dijon. In this example the ashlar piece is raked and embedded into the masonry. This construction allows Courtenay to return

[101] Courtenay, 106.
[102] Courtenay, 106.
[103] Courtenay, 109.
[104] See Yeomans (2009) for the strength of the mortice and tenon joint in tension. For a working carpenter/designer's view, Ed Levin, 'Hammer beam Roofs II', *Timber Framing* 49 (Bellingham, Washington), September 1998, p. 10. Levin comments: 'If your hammer beam tenons into the wall post [normally the wall post tenons into the hammer beam] then load is limited by tension capacity of the pegged mortise and tenon, forcing you to confront the primal (and yet unanswered) timber framer's question: What's a pegged joint worth in tension? Almost any other joint configuration is to be preferred here.' Also Steve Chapell, *A Timber Framer's Workshop* (Brownfield, Maine: Fox Maple Press, 1998), 218-20.

to the theme of longitudinal stability, as embedding the ashlars 'protected the frames against turning and hence racking.'[105]

The 'saddle bracket' (Fig. 3.22), occurring in the nave roof of Notre Dame, Paris, at around 1220, Courtenay sees as the next stage in a linear chronology of innovations at the rafter foot.[106] This feature consists of wall post, diagonal brace, and short horizontal timber – the 'saddle' – to which the tie beam is pegged. Its function is to provide structural assistance to that main timber. The use of the qualifier, 'saddle' (coined by Friedrich Ostendorf) is odd, as the configuration is simply a bracket, a fundamental construction that carpenters would have used in a variety of applications for centuries.[107] Bracing a tie beam to a wall post by means of a diagonal member was a ubiquitous construction of medieval framing. Such framing lacked, however, this separate, interposed component, the horizontal 'saddle' shown in Courtenay and Orstendorf's examples (the tie beam itself is the horizontal component in typical medieval cross-frames). For Courtenay, then, the salient innovatory feature is the 'saddle'. Courtenay continues to state that this configuration was employed in 'transferring part of the weight of the roof to a point of loading further down the wall.' Significantly, she concurs with a comment by J. T. Smith, in which he stated that this 'new technique' was introduced, '*primarily* as a means of preventing the tie-beams from turning when joints became less reliable as the timber shrank from aging and drying.' [italics mine][108] In other words, the saddle bracket, for these two critics, was again a feature introduced to augment longitudinal stability, and acted primarily as a racking inhibitor.

A pause now needs to be taken in order to challenge the aggregation of contentious argument in Courtenay's paper. A moment's consideration will confirm the absurdity of

[105] Courtenay, 107, 109.
[106] Courtenay, 109
[107] Friedrich Ostendorf, *Geschichte des Dachwerks* (Berlin, 1908), 20, 93. Patrick Hoffsummer calls these components 'cantilevered bearers', *Roof Frames from the 11th to the 19th Century: Typology and Development in Northern France and in Belgium* (Turnhout, Belgium: Brepols, 2009), 185.
[108] Courtenay, 109.

Smith and Courtenay's suggestion as to the function of the saddle bracket. The saddle bracket is 'secured [to the tie-beam] by wooden pegs' - at Notre Dame it appears by only one peg.[109] It has no mortice and tenon, spline, or tongue and groove joint. Even if skew pinned with these 'treenails' hammered through the tie beam, the brackets would offer minimum resistance to racking. The force on this single peg could be worked out mathematically, given such factors as average wind speeds and the height of the truss, but for illustrative purposes it may be useful to think of the peg as a nail and the best way of extracting that nail. The long lever of a claw hammer is the most often used tool. As a roof begins to rack, the length of the rafter is that long lever, and the wooden peg, the nail. Indeed, the insertion of the horizontal saddle, merely pegged, between the tie beam and the brace is an 'innovation' that actually reduces the capacity of the joint to resist turning. If racking prevention were really the carpenter's objective, the joint would be stronger if the saddle were removed and a brace with a long tenon were framed directly into a tie beam mortice and multiple pegged.[110]

Ease of assembly of such heavy timbers is perhaps one factor that led to the use of the saddle bracket. The carpenter could simply place the tie beam on top of the saddle, avoiding any awkward aligning of brace tenon with tie beam mortice while manoeuvring heavy timbers at a great height. Structurally, however, the obvious explanation for the use of these brackets is the correct one, especially in light of the slender scantling used for the tie beams given in the two examples at Paris Notre Dame and Meaux (Fig. 3.23). Such bracing functioned to assist the tie beam, and thus any surmounting timbers, by reducing its span. It may conceivably be argued that such support was unnecessary at Notre Dame, with its 'hanger' pendant king posts, these tension members supporting the tie beam, but Meaux does not possess such timbers. Further, as the trusses shown include queen posts framed into the tie beam at a point just beyond the termination of

---

[109] Courtenay, 109, See also illustration 'd' in Hoffsummer, 183.

[110] The mortice and tenon joint became extensively used during the thirteenth century – see Courtenay's own illustrations; also Gustave Milne, *Timber Building Techniques in London* (London: London and Middlesex Archaeological Society, 1992), 15-17; Hoffsummer, 58.

the saddle, such brackets would serve to convert part of the roofs weight into lateral thrust at a lower point on the wall.[111]

Thinking of rafters as long levers also casts doubt on Courtenay's assertion that wall plates were an early innovation inserted to obviate 'leverage caused by wind pressure' and to 'secure the tie-beams from turning.'[112] In other words, it is the wall plates that prevent the tie beams and all surmounting timbers from toppling like a domino rally. Intuitively, again it difficult to see how a peg inserted through a timber of heavier scantling, the tie beam, into a timber of lighter scantling, the wall plate, could 'secure' the tie-beam from 'turning.' Rather, the wall plate has a twofold purpose: as a timber upon which the tie beam can be located (by means of a trenched joint); and, being thus fixed at a specific span by the tie beam, as a fixing surface for the feet of the rafters in the intermediate bays. Locked laterally into place by the tie beam, the wall plate functions, therefore, to prevent rafter spread in the intermediate, un-tied bays. It also serves to distribute the weight of the rafters along the top of the wall.[113] A function of the wall plate, when combined with the tie beam, is thus to control lateral, not longitudinal, forces. It is the wall plate that is secured by the tie beam, not, as Courtenay argues, vice-versa.

In view of the above, Courtenay's assertion that the extended sole piece combined with the flying wall plate is evidence of 'the [carpenter's] attention ... focussed on achieving longitudinal stability', must also be treated with suspicion.[114] Enlarging the triangle of the rafter foot creates no additional triangulation which may resist longitudinal forces. The joints, morticed or half-lapped, at the lower ends of the ashlar strut and rafter are still subject to the same leverage imposed upon them by the rafter length. Rather, enlarging the rafter foot shows the carpenter's concern with lateral

---

[111] Such 'queen posts', unlike the central hanging timbers at Notre Dame and Meaux, appear to be have been intended as compression members, and thus would have exerted vertical weight on the tie beam. Hoffsummer calls such 'saddle brackets' 'bearers' and simply 'brackets', 181, 270.
[112] Courtenay, 95.
[113] Brunskill, 61.
[114] Courtenay, 100.

stability (discussed shortly), the flying plate providing a more secure fixing point for the compressive ashlar strut into the now suspended inner end of the sole piece. It is also possible that the 'flying plate' was an aesthetic measure, providing a pleasing termination to what would otherwise be a monotonous series of projecting timbers (in open roofs), or as a terminal fixing point for the boarding that provided the form of the 'wagon' roof, a refinement popular in the Low Countries. The 'flying plate' may also have served to maintain uniform spacing at the end of now much longer sole pieces. In any event, creating a larger rafter foot triangle by such measures shows that it is *lateral* stability that is the structural cynosure of the carpenter during this period, and not just to control spreading, but to manage lateral wind forces in ever larger and steeper roof surfaces behaving like sails.[115]

The development of the rafter foot during the Middle Ages proves that the quest for lateral stability was the carpenter's principal concern. This simple triumvirate of common rafter – ashlar piece - sole piece is remarkably effective in controlling lateral forces, and a simple experiment can be performed to establish this.

Scaled (1:20) from Courtenay's drawing of the 'archetypal example' of the extended sole piece / flying plate arrangement in the choir of the Church of St. Vincent, Soignes (Belgium), I constructed a rafter couple at the same pitch, 47°.[116] At the base of one rafter *only,* I formed a rafter foot of sole piece and ashlar piece. When leaned together on a smooth surface, the 'footless' rafter instantly slid away, while the footed rafter always remained motionless. A moment's consideration of the principles of triangulation explains why. For the footed rafter to spread, the ashlar piece must shorten, go into compression, and thus the triangulation is working in its most efficient arrangement. Extending the sole piece and moving the ashlar inwards would increase triangulation, and improve the roof's resistance to, not *longitudinal* racking (as

[115] Yeomans (2009), 180.
[116] Courtenay, 100.

Courtenay repeatedly insists), but *lateral* spread in roofs or bays without tie beams.[117] Medieval carpenters realised this, and numerous examples can be found of attempts to extend the sole-piece as far as structurally possible (Figs. 3.24 & 3.25).[118] An extreme example is in the chancel of St Mary at Quay, Ipswich (mid fifteenth-century) (Fig. 3.26).

Significantly, this enlargement of the triangulation at the rafter foot would also be beneficial in controlling lateral wind loading. While the rafter foot on the leeward side would be inefficiently (and dangerously) in tension, the ashlar post of the windward side would be in compression and contribute to the stability of the roof.[119] Collars alone are not efficient at resisting lateral wind loading, and in high roofs carpenters developed methods of scissor bracing to control such forces.[120] Courtenay's 'extended sole plate' archetype at Soignies, contains no scissor bracing. Thus, although not a particularly steep roof, the larger triangulation created by the extended sole piece would increase the resistance to lateral wind forces.

Turning to the 'extended ashlar struts', extending these timbers down the inside of the wall in intermediate trusses may display, as even Courtenay argues with regard to this innovation, the carpenter's concern of controlling lateral movement. Such timbers now become wall posts, and, as Courtenay correctly acknowledges, clip the roof truss to the masonry walls. Without any bracing, however, little thrust is moved to a lower point on the wall. One suspects that any lateral control was limited, the performance relying solely on the jointing method used for the sole piece *into* the extended ashlar. As noted earlier, under lateral thrust such a joint – either lapped or morticed – would be in tension, and would fail long before any buttressing provided by masonry. Here, then, really is evidence of carpenters addressing the problem of longitudinal stability, especially as extended ashlars were included in tie-beam trusses – trusses that exert no

[117] Interestingly, a modern safety device introduced at the foot of ladders to prevent slippage is analogous to the rafter foot. These strut-like components, extending from the rails to the ground, also create a triangle that would need to compress for the ladder to slip.

[118] See examples in Hoffsummer, pp. 170, 171, 178, 219.

[119] Yeomans (2009), fig. 8.8, p. 180.

[120] See Courtenay's illustration (after Ostendorf) of the chapel roof, Musée St Jean, Angers, p. 98, and Tours Cathedral, p. 108, for examples of scissor bracing.

lateral thrust.[121] It is hard to explain the function of these timbers in tie-beam trusses other than an attempt to prevent racking. It is odd, therefore, that regarding the 'extended ashlar', the one component that may support Courtenay's central 'longitudinal stability' thesis, she argues that they function mainly as *lateral* thrust inhibitors, a structural role in which they seem rather inept.[122]

In the light of the above, it must be re-emphasised that these 'innovations', 'where roof meets wall', are principally evidence of the carpenters' concern with managing lateral forces, not as Courtenay repeatedly insists, longitudinal forces. I have found countless examples of medieval structures – from fourteenth-century country churches to late medieval state buildings - where the masonry walls are being thrust out of plumb by the lateral forces generated by an inadequately tied roof.[123]

It is a somewhat surprising aspect of medieval carpentry that up until around the beginning of the second quarter of the thirteenth century, western European carpenters seemed little concerned with racking. Substantial roofs continued to be constructed with the complete absence of structural longitudinal timbers.[124] A consideration of the structure and situation of many early steeply pitched roofs, however, leads one to ask just why the carpenter would be so concerned with longitudinal stability. A carpenter would know that the surface area exposed to lateral wind loading is far greater than that at the gables subject to longitudinal forces. Further, the majority of the structures cited by Courtenay as examples of carpenters' struggles with longitudinal stability have masonry gables or other solid abutments such as crossing towers which would intrinsically limit longitudinal wind-loading.[125] The few roofs cited that terminate as timber structures,

---

[121] Courtenay's figs. 13 and 15b.

[122] Courtenay, 106-109. See also the comments of Levin, nt. 104.

[123] Three examples: Cotton Church, Suffolk; Idlicote Church, Warwickshire; Eltham Palace, Greater London.

[124] In France, choir of Bayeux Cathedral, 1227-28d. In England, Wells, nave; 1212-1213d; Lincoln, St. Hugh's Choir roof, 1201±5d. See also Eric Mercer, *English Vernacular Houses: A Study of Traditional Farmhouses and Cottages,* (London: HMSO, 1975), 79.

[125] See Yeomans (1985), 62. As Yeomans later points out (2009, pp. 188, 189), in some English cathedral roofs with masonry abutments, carpenters showed little interest in preventing racking, and remedial action had to be taken in the 18th century. This was still, however, around 450 years after their construction, proving, perhaps, that the carpenter was right not to have longitudinal stability as his immediate concern.

such as above the eastern apses of French cathedrals, invariably have hipped roofs, the jack rafters of which, the carpenters may have believed, serving as props to help counteract racking, at least in one direction.[126]

Notwithstanding the nature of their terminations, the roofs of such major French cathedrals are extremely long, and questions must rightly be raised about their longitudinal stability. The carpenters at Meaux Cathedral and Notre Dame, Paris, did indeed address such problems, not, as Courtenay argues, by means of the pegged saddle bracket, but through systems of bracing from queen and king struts to longitudinal plates.[127] Strangely, Courtenay does not mention these important and innovatory braces. Further, it must also be remembered that throughout the Middle Ages, buildings of prestige (and buildings subject to extremes of weather) had timber sarking boards fixed to the tops of the rafters. Sarking boards were essential for the support of the lead covering used on the roofs of such high status buildings.[128] For tiled roofs of un-vaulted structures, these longitudinally applied boards would have served an aesthetic purpose, hiding unsightly battens and underside of the tiles. Crucially, however, creating a continuous diaphragm over the entire roof surface by means of sarking inherently

---

[126] **Bayeux Cathedral**: the n. transept gable is masonry, the short roof abuts the main masonry body of the building; **Fritzlar Cathedral**, (central Germany): choir roof has masonry gable above a hipped roof of a lower semi-circular apse, the west end abuts a crossing tower; **Church of St Vincent, Soignies** (Belgium): choir has masonry east gable and abuts a crossing tower in the west; **Church of Our Lady, Damme** (Belgium), open roof, east end propped up by hipped roof over apsidal termination; **Reformed Church, Oirschot:** (Netherlands): small structure, masonry gables; **Rolduc Abbey Church**, (Netherlands): masonry structure; **St. Gatien's Cathedral, Tours** (France): hipped roof over apsidal termination of choir**; Notre Dame**, **Paris**: hipped roof over east apse, masonry twin west towers, long roof; **Meaux Cathedral:** long roof, masonry gabled at the west, hipped at the east.

[127] Admirably disclosed by Épaud, 188; see also Hoffsummer, 183, 184. A similar system is found in the nave of Winchester Cathedral, possible contemporary with the main structure of 1246-1250d, but probably inserted c. 1400. If belonging to the later date, carpenters evidently saw the system as an effective racking inhibitor. Hewett, 1985, 42, and 1980, 157.

[128] C. F. Innocent, *The Development of English Building Construction* (Newton Abbot: David & Charles, 1971 [1st ed. 1916]), 277. Under-lead sarking boards were used at Salisbury Cathedral, 1251/52d, D. H Miles; M. J. Worthington, 'Hampshire Dendrochronology Project – Phase Seven', *VA*, Vol. 32 (2001), p. 79.
Lead was introduced early for use as roof covering in England and France. Bede says that Lindisfarne was covered in lead in 688. York Minster roofed with lead c.669; Choir of Canterbury, 1093 – 1130, Charles Singer et al., *A History of Technology* (New York & London: Oxford University Press, 1954–1958), Vol. II, 429. The sarking timbers apparently were also called 'ledlathes', and 'thacking', Salzman, 241, 243.

contributes to longitudinal stability. Any tendency in the roof to rack would have been impeded by such planking, allowing the carpenter to concentrate on the more pressing problem of lateral forces.

Remaining with the theme of lateral forces, imprecision is also encountered in Courtenay's repeated statements that extended ashlar posts and saddle brackets resting on corbels moved the *weight* of the roof further down the wall.[129] It is counterintuitive to think of the entire weight of the roof resting on puny corbels - indeed, upon investigation, many medieval corbels reveal a gap between the 'supported' post and the upper surface of the corbel.[130] Rather, in general, wall plates resting on masonry walls take the weight of the roof. Extended ashlars in un-tied trusses were, however, an attempt by the carpenter to move the *thrust* of the roof to a lower, more stable, position, and thus again evidence of carpenters' attempts to control lateral movement of the roof frame. The saddle bracket, by its very nature, would convert a proportion of vertical weight into horizontal thrust. It is the way any bracket works. A bracket, to be secure vertically, needs only to be fixed at the top, as any weight placed upon it pushes the lower portion against the wall. Think of a simple bracket for a bookshelf. It will rarely fail because it slides vertically down the wall. It will never fail because the lower screw (analogous to the masonry corbel) works loose – this is thrust against the wall by the weight of the books. But it will certainly fail if not firmly secured at the top.[131] Thus the bracket in Courtenay's illustration of the choir roof in Meaux Cathedral is a highly

---

[129] Courtenay, 109, 113, 116.

[130] My own observation; Cautley, *Suffolk Churches …* (5th ed., 1982), 90; he also argues that wall posts are suspended components. Many fifteenth-century church hammer-beams dispense with corbels completely, showing that it was lateral thrust, rather than vertical weight, the carpenter was concerned with. Church hammer-beams *sans* corbels: Worlingworth, Suffolk; Grundisburgh, Suffolk; South Acre, Norfolk, among many others. Courtenay and Robert Mark, later argue that the weight of the unique roof at Westminster Hall is borne by the corbels, 'The Westminster Hall Roof: A Historiographic and Structural Study', *Journal of the Society of Architectural Historians,* Vol. 46, No. 4 (Dec., 1987) pp. 374-393. This contention is discussed at length in Chapter 6 of this thesis.

[131] This is not to say there is *no* vertical weight at the lower point on a vertical member of a strutted bracket, the longer that member (in proportion to the horizontal member), the more the vertical weight is increased. For a more detailed explanation of the function of a bracket by a structural engineer, see Yeomans (2009), 9-11, 19, 20.

efficient arrangement.[132] The 'saddle' extends across the masonry and is pinned there by tie beam and in turn by the rafter. The vertical load placed upon it by the 'queen posts' is converted to diagonal thrust with little danger of the bracket pulling away from the top of the wall, and no vertical 'weight' on any lower corbel.

Courtenay's Hammer-Beam Antecedents

Up to this point, the preceding has been a consideration of Courtenay's interpretation of certain carpentered innovations introduced in the twelfth and thirteenth centuries in western central Europe. It should be remembered that her intention was to investigate 'hammer-beam antecedents', and this aspect of the paper is now addressed.

Courtenay's arguments with regard to the 'saddle bracket' as a hammer-beam precursor are doubtful. The saddle at Meaux, extending as it does through the wall, certainly is reminiscent of the hammer beam in the bracket arrangement in the lower portion of a hammer-beam truss. Superficially, the brackets at Notre Dame, taken in isolation with what she dubs the 'purlin post' and the 'purlin' bear a resemblance to later hammer-beam construction – provided one magically removes the tie beam from the picture.[133] Crucially, however, these brackets directly support, not roof timbers, but such tie beams, and thus have little in common with a hammer-beam construction. Rather, they are simply examples of 'brackets', autonomous strutted constructions whose origins are lost in the mists of time. If the 'saddle bracket' is an antecedent of the hammer-beam, then any bracket can be deemed such - from those that held up medieval scaffolding and staircases, gibbets, to brackets that supported machicolations and jettied structures (Figs. 3.27-3.29).[134] The bracket is a fundamental architectural component. In

---

[132] Courtenay, 114, 115.

[133] Courtenay, 112, 113, although this 'purlin', not supporting common rafters, has little in common with the standard definition of a purlin.

[134] Klaus Zwerger, *Wood and Wood Joints: Building Traditions of Europe and Japan* (Basel: Birkhauser, 1997) p. 134, has a medieval illustration of a bracket-supported timber fortification atop masonry ramparts. Gunther Binding's, *Medieval Building Techniques* (Stroud: Tempus, 2004), contains many contemporary illustrations depicting scaffolding supported by brackets, the earliest c. 1200; illustrations 183, 268, 315, 346, & 354 are particularly instructive. John Fitchen's *The Construction of Gothic Cathedrals* (Chigago & London: University of

thinking about hammer-beam development, it is not the component, but the concept - the idea that the bracket could be used in a revolutionary new way - which is salient: at some point in history a carpenter had the inspiration that a bracket could be expedient to reduce the span of a roof.

The extended sole piece and overhanging ashlar configuration is a more convincing hammer-beam antecedent, redolent, as it is, of the developed hammer beam and hammer post arrangement. It lacks, however, the lower bracket, so fundamental to hammer beam construction. While hammer beams without this lower bracket are found in many fifteenth-century East Anglian Churches, these are decorative, structurally impotent features.[135] Courtenay's example of the intermediate truss in the roof of the Reform Church at Oirschot, (Netherlands) dated to *c.* 1290, perhaps bears the closest resemblance to a hammer-beam truss, but its evidence is only suggestive (Fig. 3.30).[136] Here, a sole piece extends to a flying plate which in turn supports an arch brace to rafter. Above that is an arch brace to collar. If one isolates a single common-rafter truss, and removes the flying plate (which has *nothing* in common with hammer-beam construction) here is almost a prototypical East Anglian hammer-beam. If only the carpenter had thought to insert a bracket to support the sole piece. But there was no need, as this is not a hammer-beam roof but a tie-beam roof, and the sole piece via the 'flying plate' receives its support from adjacent tie beams. If one is to view this structure as a hammer-beam precursor, the above, somewhat strained, similarities are in any case irrelevant, as the date of *c.* 1290 is problematic. By the 1290s a fully developed hammer-beam structure was probably in place in the kitchen of the Bishops Palace in Chichester, and almost contemporaneously in the Pilgrims' Hall in Winchester.

Chicago Press, 1961), 160, illustrates bracket-like structures in the lower portions of framework constructed to support the centering used during the construction of cathedral vaulting. Salzman, plate 17, has a fourteenth-century illustration of a gibbet as part of a crane.

[135] For example, Chapel of St Nicholas, King's Lynn, Norfolk (*c.* 1400-19). These components are discussed extensively in Chapter 8 of this thesis.

[136] Courtenay, 103.

Finally with regard to hammer-beam antecedents, the 'extended ashlar strut' is even less convincing. It is a development that, with the addition of a curved brace, more logically leads to the arch-braced cross-frame.

Courtenay's original and thought-provoking paper is let down by being rooted in the fundamental misconception that these innovations at the foot of the rafter were 'developed chiefly to improve longitudinal stability in large scale roofs': roof *rack* rather than roof *spread*.[137] And yet features that she interprets as carpenters' attempts to contain longitudinal forces may just as easily, and more logically, be interpreted as attempts to deal with lateral wind forces and thrust in steeper, larger roofs. Indeed, the evidence suggests, with the extensive use of sarking and the masonic nature of the structures, that carpenters were little concerned with the problem of longitudinal thrust.

With regard to Courtenay's stated aim of establishing 'hammer-beam antecedents,' the evidence is inadequate and conclusions are conjectural. The various innovatory components may suggest a separate, continental, hammer-beam genesis in masonry buildings, which then followed a distinct developmental path independent of that followed by early English examples derived from timber-framed aisled buildings. But if the bracket and the overhanging rafter foot truly are antecedent components of hammer-beam roofs, then it is their conflation that would be the crucial development, and evidence of this from the Low Countries is absent. If such continental carpenters developed hammer-beam antecedents, why did not they exploit their innovations and develop the hammer-beam roof? From the evidence of the extant buildings in the Low Countries and Northern France, such structural innovations produced no tradition of hammer-beam roofs. The reasons for this may range from differing carpentry traditions to matters cultural and aesthetic. Nonetheless, such an absence indicates that these innovations are not evidence of carpenters groping their way towards fully developed hammer-beam roofs, but merely empirical solutions to a given structural problems at a

[137] Courtenay, 121.

specific time. Indeed, it must be adduced that an inherent contradiction runs through the paper: how can components, which Courtenay contends were for designed for longitudinal stability, be argued as hammer-beam antecedents, a construction that is a solution to lateral demands.

Despite major reservations, Courtenay's paper is a valuable insight into the medieval carpenters' struggles and consequent innovations to deal with barely comprehended structural forces. It shows the carpenter to be an empiricist, always testing and improving. Importantly, notwithstanding her opening statement that the hammer-beam was 'a roof type that developed exclusively in England in the fourteenth century', Courtenay's paper opens up further research questions regarding the influence of the Netherlands and Northern France upon English carpentry in the thirteenth and fourteenth centuries.[138] The Low-landers may not have developed the hammer-beam roof - but did any of their innovations cross the channel to influence English carpenters? Perhaps structural seeds from the Low Countries of the twelfth and thirteenth centuries contributed, in a small way, to the ultimate blossoming of the hammer-beam in the English lowlands of fifteenth-century East Anglia.

Hammer-bean antecedents in Courtenay's paper ultimately prove to be sparse. English candidates, however, in both carpentry tradition and carpentry innovation, can be found. Building on my comments on bracketed, cantilevered structures, in the following chapter I will propose a number of hammer-beam antecedents of my own.

---

[138] Courtenay, 89.

Chapter 4

STRUCTURAL PRECURSORS AND FOURTEENTH-CENTURY DEVELOPMENTS

In my previous chapter I critiqued Professor Lynn Courtenay's 1985 paper on hammer-beam antecedents which she found principally in Europe. In this chapter I propose some of my own, mainly English, structural embryos which contributed to the inception of the hammer beam at the turn of the thirteenth century. Fourteenth-century developments are then evaluated, including determining just which was the earliest hammer-beam roof. In a departure from mainstream academic opinion, I will then go on to argue that aisle-derived fourteenth-century hammer-beam construction proved to be a structural and formal dead-end.

PRECURSORS: BRACKETS

Brackets are commonplace constructions to which many of us would not give a second thought, and yet in the context of medieval carpentry, these simple strutted components were crucial to the development of the hammer-beam roof. For late medieval carpenters, the construction of brackets and the insertion of struts would have been a fundamental, almost daily, activity. We have seen already seen examples that supported machicolations and jettied structures, and medieval illustrations show brackets further being used in a variety of other ways, such as to support scaffolding and overhanging architecture, and as integral to the construction of medieval lifting devices (Figs. 4.1-5; see also Fig. 3.29). At Stokesay Castle, brackets support an internal staircase, and an external jetty (Figs. 3.27 & 3.28), and John Fitchen suggested that, rather than a series of long timbers, some form of strutted components were used to support vault centering.[1] In all these cases, the diagonal strut of a bracket replaces a vertical member it would be either unfeasible or inconvenient to employ. The same is true in a hammer-beam roof. Fundamental to the purpose of the bracketed components of a hammer-beam roof is that they are used in opposition to span a substantial void. Significantly in this search for antecedents, evidence exists that medieval carpenters were using such opposing brackets to span voids before the advent of the hammer-beam roof.

A contemporary source often used to study medieval construction techniques is the thirteenth-century portfolio of Villard de Honnecourt, and hammer-beam antecedents can be found amongst his drawing – although not in the usually cited place.[2] Folio 17r has in turn been propounded and debunked as displaying nascent hammer-beam construction (Fig. 4.6).[3] Here, illustrated in two sketches, a projecting horizontal timber supports a vertical timber as the carpenter sought to broaden the rafter foot. In neither case, however, and notwithstanding the sag of the sole piece evident in the lower of the two examples, did the carpenter think to insert a strut and wall post to complete a hammer-beam configuration. Whether these two drawings are evidence of hammer-beam precursors is a moot point, but they at least show the thirteenth-century carpenter interested in managing unsupported span, even if forced into the solution by the necessity to clear the extrados of a vault. Nonetheless, even if we disregard folio 34, Villard's sketchbook is still crucial for the hammer-beam researcher – it is simply that previous scholars have been looking at the wrong folio.

---

[1] John Fitchen, *The Construction of Gothic Cathedrals* (Chicago & London: University of Chicago Press, 1961), 160. For examples of brackets from thirteenth-century illuminated manuscripts see Gunther Binding, *Medieval Building Techniques* (Stroud: Tempus, 2004), 268, 315, 346, 354.

[2] Bibliothèque Nationale de France (MS Fr. 19093), compiled *c*. 1220-40.

[3] For opposing views on this folio and its pertinence to the hammer-beam roof, see John Harvey*, Gothic England* (London, Batsford, 2nd ed., 1948), 51-52, and John Crook, 'The Pilgrims' Hall, Winchester, Hammerbeams, Base Crucks and Aisle-Derivatives', *Archaeologia* 109 (1991), 150-151. In the most recent analysis of Villard's portfolio, Carl F. Barnes, *The Portfolio of Villard De Honnecourt: A New Critical Edition and Color Facsimile* (Farnham: Ashgate, 2009), the author calls the roof depicted 'a simple hammer-beam roof', 109.

Midway down folio 20r, and easy to overlook, is a tiny drawing resembling an assemblage of modern iron girders (Fig. 4.7). This is the author's suggestion of how to construct a timber bridge of substantial span. His comments are brief, but vital: 'In such a way one makes a bridge over a river with 20 foot beams.'[4] The first thing to note, then, is that Villard's bridge is constructed of relatively small, easily obtained and converted timbers, in order to span a void greater than those timbers' individual dimensions. The sum of parts creates a greater whole. The same is true of a hammer-beam roof. In both constructions shorter timbers replace long beams and posts – the longer, heavier timbers in the case of a bridge perhaps unfeasible, in the case of a hammer-beam, unwanted or unobtainable. These short timbers are only able to be used, and this is the second salient point, because they are carpentered into a system of brackets. Thus, Villard's lower bracket goes on to support a post and a strut which in turn forms another bracket carrying the horizontal timbers of the roadway. Identical carpentry principals are employed in the construction of a hammer-beam roof; indeed Villard's lower bracket is remarkably homologous to generic lower hammer-beam framing, but rather than a road, the brackets in a hammer-beam support a roof covering. This latter point can be demonstrated graphically. As can be seen from Fig. 4.8, one can recognise the basic configuration of a hammer-beam roof in the framing of Villard's bridge.

Incidentally, Villard's drawing even features the, possibly structurally superfluous, diagonal, post to strut, cross-bracing. The carpenter probably thought of these as tension members, preventing the struts from buckling outwards under compression.[5] Significantly, though soon discarded, this type of cross-bracing was a feature of English carpentry at the end of the thirteenth century, and of the very earliest hammer-beam roofs in the south of England (see figs. 4.25 & 4.31).

The point to draw from this brief discussion of Villard's folio is that north-west European carpenters in the mid thirteenth century were adept at carpentering short

[4] The original text: 'Par chu fait om on / pont desor one aive / de fus de .xx pies de lonc.'
[5] From the framing and pegging of these components in Viollet-le-Duc's illustration (Fig. 4.7), he obviously thought these diagonal timbers to be in tension.

timbers into bracketed components in order to span a void. When, after the turn of the century, the demand arose for the removal of posts in a seigneurial hall or a busy kitchen, this proficiency merely needed to be adapted to provide a solution to new exigencies of an unsupported roof span. The hammer-beam roof was the result. To reiterate, the short-timber bracket technology was in place; it just needed a moment of inspiration to use the technology to sustain a roof. Perhaps the source of such inspiration should be sought in roof-carpentry techniques at which thirteenth-century carpenters were already adept.

CORBELLED WALL POSTS, TIES, PURLIN AND PLATE STRUTS

As the nomenclature becomes more banal, reassuringly the inferences become more intriguing. Stokesay Castle has already been adduced as a thirteenth-century structure containing carpentered architectural brackets. But similar components, this time associated with the roof carpentry in the Great Hall at Stokesay, may supply one source for the concept that brackets could be used to a manage roof span, because with different structural intent, such brackets are already present in the roof.

Set upon corbels on the gable walls in the hall are wall posts, and from the base of these wall posts rise diagonal struts (Fig. 4.9). At their upper terminations, by means of a birdsmouth joint (see *Glossary*), the struts are framed into purlins. Similar corbels, wall posts and struts, with the design intent of supporting a purlin, are found in an earlier hall, the Old Deanery, Salisbury (*c.* 1265), and in a structure coeval with Stokesay, the crown-post roof in the solar at Old Soar Manor, Plaxtol, Kent (Figs. 4.10 & 4.11). At Plaxtol they are framed into a square-set crown plate. It seems that the corbelled wall post and strut was a common form of solution for terminal purlin/plate support in the un-hipped, masonry gable walls of halls and barns during the thirteenth and fourteenth centuries. Further, and earlier, examples of the construction are found in France, in the Grange du Val-de-la-Haye (Seine Maritime, 1216-20d), and also in a barn at

Heurteauville (Seine Maritime, 1237-1243d).[6] Early fourteenth-century English examples are at Great Coxwell Barn, Oxfordshire (1300-1310d)[7] (Fig. 4.12), and Middle Littleton Tithe Barn, Worcestershire.

If one ponders such corbel, wall post and strut framing on site, all designed to support a horizontal timber, hammer-beam framing is inevitably suggested. Clearly, the structural function of the above examples is not analogous to the transverse brackets of a hammer-beam. No lateral thrust needs to be managed; these are longitudinal components, intended to stiffen the purlin or plate before its load is taken by the wall. My suggestion is, however, that it only required an epiphanic moment in a carpenter's imagination and the structural role of a widespread contemporary component might be transformed, to become a means of supporting arcade plates (via a hammer post), not longitudinally, but transversely.

The idea to transform the structural role of another component found in aisled structures may also have given rise to the hammer-beam roof. Aisle ties (Glossary, Fig. B) are intrinsic to the construction of timber-framed aisled buildings, *and*, significantly, examples braced to corbelled wall posts are found in at least two English aisled structures which either pre-date or are contemporaneous with the advent of the hammer-beam roof: Leicester Castle (*c.* 1150d) and Great Coxwell Barn (Figs. 4.13 & 4.14).[8] For the carpenter, it seems that the aisle tie's function was multiple. It served to tie the wall plate to a heavy main structural timber, the arcade post, and thus served to counteract lateral thrust in the roof. When arch-braced to a wall post, as at Leicester and Great Coxwell, they must have provided lateral stiffening to the frame. The aisle tie also had a spatial function of serving to compartmentalise the bays, and perhaps provide fixing points to which partitioning materials could be attached (see Fig. 4.24). Thus separate

[6] Illustrated in Frédéric Épaud, *De la Charpente Romane à la Charpente Gothique en Normandie: l'évolution des techniques et des structures de charpenterie du XIIe au XIIIe siècles* (Caen: Publications du CRAHM, 2007), 556-7, 565-568.

[7] Since this thesis was submitted for examination, a more precise tree-ring date for Great Coxwell has been established of 1291/92, *VA* 45 (2014), 123.

[8] It must be admitted that, while braced aisle ties are shown in Fig. 4.13, no direct evidence exists for their existence. I am grateful to Professor Nat Alcock for pointing this out to me. A minor French example of this type of framing dating to 1219/20 is in a barn at Sant-Lazare de Beauvais, Oise. Illustrated in Épaud, 234.

zones are created - a useful expedient in barns and for overnight guests in medieval great halls.[9] The slight scantling of the aisle-tie timbers reflects their function. Nevertheless, again observing the framing when the aisle tie is arch-braced to a corbelled wall post, and keeping in mind that the aisle tie continues through the wall head to be pinned by the rafter, one is immediately struck by its affinity to lower hammer-beam framing. Did a carpenter of an aisled barn once ponder such framing and perceive an alternative structural role? By increasing the scantling of his tie and transforming it into a bracket, the bracket would permit him to saw off his aisle posts and create the uncluttered floor-space supplied by a hammer-beam roof.

We can go some way to understanding the carpenter's thought processes by thinking about the framing in the barn at Ter Doest Abbey, Lissewege, Belgium (1365-85d) (Fig. 4.15). There, the carpenter was evidently seeking a method to assist the intermediate frames which have no supporting posts. His solution was to repeat the framing of the aisle ties, but shorten the tie to create a hammer beam, and then insert a strut to stiffen the rafter. Thus, at Ter Doest, we have an example of a carpenter adapting aisle-tie framing in order to create, albeit minor, hammer-beam frames. The carpenter at Ter Doest was not seeking to completely clear the floor of posts. Nonetheless, in an English context, corbelled wall post with braced aisle tie construction is intriguing. Its transverse placement, its visual and structural similarity, and its chronological correspondence place the corbelled and braced aisle tie in the category of potential hammer-beam antecedents.

A similar rationale may be applied to a final situation in which corbelled wall posts and struts supplied a structural solution immediately prior to the appearance of the hammer-beam roof. At Wherwell Abbey (1250d and 1280d) in Hampshire, the heartland of hammer-beam development, they are found laterally bracing tie-beams (Fig.

---

[9] For the workaday function of bays in medieval aisled structures see Michael Thompson, *The Medieval Hall* (Aldershot: Scolar Press, 1995), 26-27.

4.16).[10] Now the carpenter would have to increase the scantling only of the wall post and strut, and perhaps engage the mason to build a corresponding external buttress, before he could excise the central section of the tie beam and thus create a hammer-beam cross-frame, in which queen struts become hammer-posts. In this scenario the hammer-beam roof would have been the result of headroom concerns rather than the desire to remove vertical posts. The perennial problem of sourcing large tie-beams may have again been the impetus.

The splendid monastic barn at Great Coxwell has been mentioned, so now may be the moment to address previous contentions for the barn as the location of a hammer-beam antecedent. According to Horn & Born in their admirable 1965 account of Great Coxwell, the framing contains 'a germinal form of hammer-beam construction', a view reiterated by Lynn Courtenay in 1984 and 1985.[11] These 'germinal' forms appear in the intermediate, raised base-cruck, transverse frames (Fig. 4.17).[12] Because the base-cruck terminates at the arcade plate, the upper purlins need a substantial timber to provide support between the main, post and beam, frames. In the main frames such support is achieved by means of an elbow-braced principal (a rafter of heavier section, but here could equally be termed a 'parallel rafter') framed into the tie-beam. With no tie-beam on the intermediate crucks to tenon a parallel rafter into, the carpenter introduced the 'germinal … hammer-beam': a stub tie-beam, supported by an acutely angled brace. The

---

[10] Illustrated and briefly discussed in John Walker (ed.) *The English Medieval Roof: Crownpost to Kingpost* (Essex Historic Buildings Group, 2011), 53.

[11] Walter Horn and Ernest Born, *The Barns of the Abbey of Beaulieu at its Granges of Great Coxwell & Beaulieu-St Leonards* (Berkeley: University of California Press, 1965), 7. Courtenay: the 'hammer-beam … appears in rudimentary form in the intermediate truss of the barn at Beaulieu, Great Coxwell', 'Westminster Hall and its Fourteenth-century Sources', *Journal of the Society of Architectural Historians*, Vol. 43, No. 4 (Dec. 1984), 296, nt. 11); in 'Where Roof Meets Wall: Structural Innovations and Hammer-beam Antecedents', in Pamela O. Long ed., *Science and Technology in Medieval Society* (New York: The New York Academy of Sciences, 1985), 105, she refers as to the Great Coxwell component as a 'proto-hammer-beam',.

[12] F. W. B. Charles, *Conservation of Timber Buildings* (Shaftesbury, Dorset: Donhead, 1984), refers to these timbers as 'false crucks', but with some justification prefers the term 'curved principals', p. 27.

purpose of this strutted construction is thus to provide a platform for a secondary, parallel rafter, which rises, assisting the purlins, to a collar.[13]

It is dubious to judge this tiny component as a precursor of hammer-beam construction. It has nothing in common with hammer-beam construction of heavy timbered main cross-frames, a construction which is concerned with managing the span of an unsupported main frame. Nonetheless, it again points to a resourceful and adaptable craftsman using familiar bracket construction to respond to a specific structural challenge: providing upper purlin-support in the intermediate base-cruck frames of an aisled building.

Whatever the merits of this 'germinal' component, discussion of Great Coxwell as a minor font of hammer-beam construction is, in any case, redundant. Horn & Born, and Courtenay, without the benefit of later tree-ring analysis of the Great Coxwell timbers, believed the barn to date from the early thirteenth century. Now, however, Great Coxwell has been tree-ring dated to 1300-1310. As the great barn was being constructed, therefore, fully-formed hammer-beam roofs were already being crafted by carpenters a hundred miles or so south, in the cathedral precincts of Chichester and Winchester.

SALISBURY: THE EARLIEST HAMMER-BEAM ROOF?

More convincing, both chronologically and structurally, germinal hammer-beams are found in the carpentry of the north triforium of the nave of Salisbury Cathedral.[14] Now tree-ring dated to 1252, the carpentry here is advanced and rightly celebrated.[15] Inconspicuous and unremarked upon in the literature, however, at wall plate level at the

---

[13] A similar, though not identical, construction is found in Titchfield Abbey Barn, Hampshire, 1408-9d. See Walker (ed.), 54.
For the sake of clarity, I am attempting to limit descriptions of structural details to essentials. The secondary rafter, after supporting a purlin, in fact continues to a collar which itself assists the final purlin. Preventing purlin sag was, nonetheless, the main motive behind the construction.

[14] I am indebted to Clerk of Works Gary Price for permission to view the roof, and to Head Carpenter Richard Pike for showing me the carpentry.

[15] D. W. H. Miles, *The Tree-Ring Dating of the Roof Carpentry of … Salisbury Cathedral* (English Heritage, 2002); Hewett, *EHC*, 92-93; Hewett, *English Cathedral and Monastic Carpentry* (Chichester: Phillimore, 1985), 130.

point where the triforium roof intersects that of the equally noteworthy north porch, the carpenter decided to frame two brackets (Figs. 4.18 & 4.19). These configurations truly are embryonic hammer-beam structures. The wall post is present, framed *into* a 'hammer beam'; and this horizontal beam continues through the wall head to be fixed by the rafter.[16] The beam extends to be supported by a strut; and the beam in turn supports a short post (a hammer post?), which supports the rafter. In an already over-engineered lean-to roof, the carpenter evidently intended this construction to assist the span. All the above constructive elements are determinative features of a hammer-beam roof.

It would be excessive to claim this minor carpentry at Salisbury as constituting the first hammer-beam roof (which, incidentally, would wreak havoc with those concerned with bestowing 'true' or 'false' hammer-beam status). As this is a lean-to roof, they have no corresponding brackets on the opposing wall for example. Nonetheless, fifty years before the appearance of the 'first' hammer-beam roofs, here at Salisbury is the first known example of a carpenter inserting brackets, in which, crucially, the horizontal timber extends across the wall head, to assist the span of a roof.

The search for hammer-beam precursors must inevitably involve some degree of conjecture. In the preceding, through a consideration of brackets and the adaption of corbelled wall posts, I have looked at how English carpentry practice of the thirteenth century may have influenced the development of the hammer-beam roof later in the century. With the exception of Salisbury, these links are perceptual rather than patent. One final, and tantalising, potential hammer-beam antecedent is more obvious. A structure located in Chichester Cathedral may be interpreted as a crucial late step before the first fully-formed hammer-beam roof was carpentered, and its location, in the cradle of hammer-beam carpentry in central southern England, adds to its fascination.

[16] Hewett's drawing (1985, p. 130) implies that this horizontal timber may be an extension of the north porch wall plate, but it was impossible to ascertain its true nature during my examination.

Final Steps? Chichester Carpentry of the Late Thirteenth Century

The roof over the nave and choir of Chichester Cathedral is hugely important, well-studied, and rightly famous among scholars of medieval carpentry.[17] Compared to its bigger and illustrious neighbour, the minor, mundane structure over the north aisle of the choir at Chichester has, however, been neglected, and yet here is a structure of intriguing potential for the student of hammer-beam development.[18]

As expected above an aisle, the roof is of lean-to construction; it is double-framed, consisting of principal rafters only slightly larger in section than the commons; into the principals are framed purlins, which are in turn surmounted by the common rafters (Fig. 4.20). Nevertheless, in a display of technological overkill in what is a modest span, the carpenter decided to insert brackets to assist the principals. A wall post rests on a corbel and rises to a short horizontal timber which projects into the internal space (Fig. 4.21). Nomenclature here is a little difficult. 'Hammer beam' is premature; perhaps 'extended sole piece', or even 'stub tie-beam', are useful compromises. This horizontal timber is fixed by the principal at its outer end, and is framed into a strut at its inner end. The strut extends from the base of the wall post to a point on the principal approximately a third of its length. In later structures such a strut is nominated a 'sling brace.'[19]

The observer will note both similarities and disparities between the framing described above and conventional hammer-beam framing. Firstly the disparities: (i) the framing of the lean-to roof has little in common with the aisle-derived nature of early hammer-beam roofs; (ii) the framing has no vertical timber – any kind of incipient hammer post; (iii) In a reversal of usual framing, the extended sole piece is framed *into* the principal-assisting timber rather than vice-versa. The similarities: (i) as at Salisbury,

---

[17] The definitive source for the Chichester main roofs is Julian Munby, 'Medieval Carpentry at Chichester', in Alec Down (ed.), *Chichester Excavations* V (Chichester: Phillimore, 1981), pp. 229-253.

[18] I am indebted to Chichester Cathedral Clerk of Works Mr Ralph Tyreman for showing me the roofs. According to a drawing in Tim Tatton-Brown, 'The Medieval Fabric', in Mary Hobbs (ed.), *Chichester Cathedral: An Historical Survey* (Chichester: Phillimore, 1994), p 40, a similarly framed roof continues over the north aisle of the nave. I did not examine this roof.

[19] CBA, 9g. Similar, but undated, structures in French vernacular buildings are illustrated in Gwyn Meirion-Jones, 'The Roof Carpentry of Brittany', *VA* 9 (1978), pp. 22, 23.

the carpenter's intent was clearly to use a bracket structure, comprising corbelled wall post, strut and horizontal timber, to manage the span of the roof; (ii) the horizontal timber is aided in its cantilever function by the weight of the principal at its outer end; (iii) since any tendency for the rafters to sag or the roof to spread would have forced the strut down, the carpenter evidently thought of the horizontal timber as a tension member. Thus, the structural intent, the cantilevered structure and the horizontal timber as a tension member are consistent with local, then imminent, hammer-beam framing. The hammer-beam roof of just a few years later in the kitchen of the Bishop's Palace is less than 500 metres away. Furthermore, even the disparities can be found in later hammer-beam roofs. Inclined timbers, usually arcuated, often serve as hammer 'posts', and hammer beams are sometimes tenoned into hammer posts to produce the pendant form of the roof.

If the above framing at Chichester is to be considered as a hammer-beam antecedent, then the date of the roof is crucial. In 1187 a major fire engulfed much of the cathedral. Damage was extensive, particularly to the east end, and major repairs continued well into in the next century. The roof of the nave and choir has been dated to 1287 (±20/15) by dendrochronology, a date presaged by documentary sources and interpretation of structure.[20] No documentary sources are known which indicate the north choir aisle roof, presumably also destroyed by the fire, to be of a later date. Robert Willis in 1861 lamented that the 'documentary history of Chichester Cathedral is unfortunately very meagre', and in order to date the building campaigns in detail at Chichester he relied mainly on structure and style.[21] Willis stated that the church was 'Norman in the principal walls', and apart from an extension to the Lady Chapel, he describes no major works to the east end subsequent to the thirteen-century, post fire emendations.[22] Similar conclusions are reached by the VCH volume, and in the most

[20] Munby (1981), 244-5. Munby concluded that the roofs belonged to the second half of the thirteenth century.
[21] Robert Willis, *The Architectural History of Chichester Cathedral …* (Chichester: 1861), 1.
[22] Willis, 5, pl. 1, and 12-35 *passim*.

recent chronological account of the Chichester Cathedral building campaigns.[23] Here, Tim Tatton-Brown refers to no major works on the east end after the conclusion of the thirteenth century. Significantly, he calls the north aisle timbers 'medieval', and associates the framing with the thirteenth-century alterations to the masonry.[24] Thus, no major works and, indeed, no further fires, are known which would demand a post thirteenth-century replacement of the north aisle roof timbers. The authority on the cathedral carpentry, Julian Munby, concluded that 'ancient roofing survives for the entire length of the cathedral ... only the Lady Chapel and transepts have lost their roofs.'[25] It seems reasonable to conclude, then, that the roof is original and that it would have been completed contemporaneously with the major carpentry endeavours in the nave and choir. If the above, somewhat circumstantial, evidence is true, then the bracket structures of the aisle roof, therefore, were carpentered probably in the 1280s, just a few years before carpenters began the Bishop's Kitchen (*c.* 1300).[26]

Objections to these datal contentions may be made on two grounds. Firstly, just as there is no documentary evidence for the north aisle roof to be post-thirteenth century, no such evidence establishes the roof to be coeval with the thirteenth-century carpentry of the main church.[27] The second, and more cogent objection, may be made on structural grounds. The lean-to roof of the aisle is a purlin roof; the purlins are staggered (*viz.* they do not form a continuous straight line) and are butt-jointed into the principals (see *Glossary*). Butt-jointed purlins, especially when staggered, are a carpentry technique associated by some scholars with carpentry of later centuries.[28] All is not lost, however. Recent dendrochronology results have shown that butt-jointed purlins do

---

[23] VCH*, Sussex:* Volume 3 (1935), pp. 116-126. Tatton-Brown , 25-46; see also the 'phased plan' of the cathedral in the same volume, pp. XX-XXI.

[24] Tatton-Brown, 42, where there is also an excellent photograph of the roof; see also annotated diagram, p. 40.

[25] Munby (1981), 231.

[26] The date of this roof is discussed later in this chapter.

[27] The choir aisle roofs were not included in the dendrochronology programme of 1992, *Vernacular Architecture* 23 (1992), 54.

[28] J. T. Smith, 'The Reliability of Typological Dating of Medieval English Roofs', in R. Berger (ed.), 1970, p. 256; Eric Mercer, *English Vernacular Houses: A Study of Traditional Farmhouses and Cottages* (London: H.M.S.O., 1975), 79-95; Munby (1981), 247; *EHC*, 203, 322, 323.

occur in late thirteenth-century roofs, in structures as far apart as Leicestershire and Somerset, and the technique becomes increasingly common from the turn of the century onwards.[29] The fact that the purlins are butt-jointed, then, does not inevitably prove the north aisle roof to be later – the structure may simply hold the earliest examples of the staggered, butt-jointed purlin.

Perhaps clues to the date of the roof may be found in the sustaining masonry. The top few courses of the external wall of the aisle are different in character from that of the lower masonry. These courses were probably added following the 1187 fire as part of the repairs,[30] or as part of a stylistic change to the aisles at the east end, from apsidal to square terminations.[31] Into this masonry are embedded corbels – corbels evidently designed to support the brackets of the roof. The roof, then, ought to be coeval with the insertion of the corbels. Further, the corbels and the roof must constitute an early structure because later minor repairs and additions have been made to the masonry of the north wall. In a number of instances the corbels have been built over and the wall posts sawn-off. The corbels and wall posts must precede these later alterations. Some headway could be made, therefore, in ascertaining at least a *terminus ante quem* for the roof if the date of these alterations were established. Finally, in the absence of dendrochronology, tool marks could be examined and compared with those of the carpentry in the main vessel to establish similarities or disparities.

To précis my comments on this intriguing, if simple, structure: were the roof of the north aisle of the choir to be coeval with the carpentry of the main roofs of Chichester Cathedral, then the bracket structures may suggest a carpenter's final, small-scale experiments with bracket components as a thrust-managing device immediately

[29] **Ulverscroft Priory**, Leicestershire, Prior's Lodging 1223-90d, illustrated and discussed in N. J. Baker, 'The West Range of Ulverscroft Priory and its Roof', *Leicestershire Archaeol. & Hist. Soc. Trans.* 56 (1980-1), pp 10-17. **Butleigh**, Somerset, Bridge Farmhouse, 1277-1309d. Early fourteenth-century examples of tenoned butt-purlins: **Lustleigh**, Devon, The Old Rectory, 1301-1326d; **Shutlanger**, Northamptonshire, The Monastery, 1304-1314d., illustrated in Paul Woodfield, 'The Larger Medieval Houses of Northamptonshire', *Northamptonshire Archaeology* 16 (1981), pp 181-185.

[30] Personal communication with Mr Ralph Tyreman.

[31] Hobbs (ed.), xx - xxi.

before carrying his tools a quarter of a mile and commencing the kitchen roof in the Bishop's Palace. Did he look at those extended inclined struts and conclude that braced vertical posts would be better? The date of the roof, however, cannot be established with certitude. A further dendrochronological survey, therefore, might just confirm an intriguing insight into carpenters' deliberations immediately before the construction of one of the earliest hammer-beam roofs.

THE EARLIEST HAMMER-BEAM ROOFS

Dendrochronology has now proved the existence of three candidates for the earliest extant fully-formed hammer-beam roof. Two, the kitchen of the Bishop's Palace, Chichester (1293-1320d), and the Pilgrims' Hall in Winchester (1310/11d), have already been the subject of some discussion in this thesis. The third candidate is in the hall of Tiptofts Manor, Wimbish, Essex, now tree-ring dated to 1282-1327d (Fig. 4.22). The three buildings are summarised in the table below.

Table 4.1

BUILDING	DATE	PURPOSE OF STRUCTURE
Bishop's Kitchen, Chichester	1293-1320d	Kitchen
Pilgrims' Hall, Winchester	1310/11d	Unknown, possibly a guest house for pilgrims.
Tiptofts Manor, Wimbish, Essex	1282-1327d	Hall

From the table it is clear that the wide parameters of two of the dates mean that any of the above three examples may be the earliest. I have, however, placed the structures in putative date order, as some progress can be made in refining the dates for these candidates.

Tiptofts (figs 4.22-4.24) has the widest datal parameters of the three early hammer beams, and those give a median of 1304/5 ± 22, compared with that of the Bishop's Kitchen for 1306/7 ± 13. If we approach the problem by working crudely from the medians, Tiptofts would be the earliest structure.[32] Sadly, little documentary evidence exists which may assist in providing a more precise date for Tiptofts.[33] Dates previously ascribed by numerous scholars are consistent, ranging from 1325-1367, and were determined mainly from the interpretation of style and structure, and the possibilities that Tiptofts was built either by Sir John de Walton (called by other writers 'Wantone' or 'Wauton') (d.1347), or by Sir John Tibetot owner of the hall from 1348-67.[34] Typical of such ascriptions is that of J. T. Smith in 1955 who wrote that 'both the collar-beam and the curved braces below it show the wave-moulding characteristic of the middle part of the 14th century.'[35] This consistent ascription of Tiptofts, on stylistic, structural and tenurial evidence to the second quarter of the fourteenth century and later suggests, therefore, that the hall belongs to the later reaches of the dendrochronological circumscriptions.

A caveat, however, must be addressed here. According to some scholars, Tiptofts was not originally of hammer-beam construction. Middleton in 1890 implied, and the writers of the RCHME Essex *Inventory* ... in 1916 likewise contended, that Tiptofts, a structure of three unequal bays with a narrow screens bay at the south end delineated by a spere truss, was originally a conventional aisled hall with a full complement of arcade

---

[32] Richard Harris commented that to dendrochronologists medians are unimportant, since the tree could have been felled any time during the established parameters. Comment made during his lecture 'The Fruits of Dendrochronology: New Insights into Roof Carpentry in England, Germany and France', *Construction History Society Conference,* Cambridge, 14/04/2014. See Miles (2006) *passim* for a more considered view.

[33] The most complete account of Tiptofts is sadly unpublished: John Walker, *Tiptofts, Wimbish, Essex: Report of Architectural Survey* (2008). I am indebted to Mr Walker for providing me with a copy of his report.

[34] Previously held dates: '**1330s'**, RCHME *Essex,* Vol. I (1916), p. 351. '**1347-68**', J. T. Smith, 'Medieval Aisled Halls and their Derivatives', *Archaeological Journal CXII* (1955), 90. '**1350-60**', Smith, 'Medieval Roofs: A Classification', *Archaeological Journal*, Vol. 115, (1958), 123. '**1348-1367**', Margaret Wood, *The English Medieval House* (London: Bracken Books, 1983, first pub. 1965), 315. '**1325'**, Courtenay (1984), 296, nt. 11. '**1335'**, Courtenay, Untitled Review of *The Medieval English Domestic Timber Roof: A Handbook of Types* by M. R. Bismanis. *Speculum* , Vol. 65, No. 3 (Jul., 1990), 615.
See also the comments of, John Walker (2008) 1-2; David Stenning in Walker (ed.) (2011), 36; Cecil Hewett, 'Aisled Timber halls and Related Buildings, Chiefly in Essex', *Transactions of the Ancient Monuments Society*, 21 (1976), 57.

[35] P. 30.

posts. At some later date the arcade posts of the central truss were sawn off and hammer beams inserted.[36] Comment on this contention by later writers is conspicuous by its absence. Details of structure at Tiptofts, however, counter the opinion of Middleton and the RCHME.[37]

We need to begin with the logical assumption that, if the central frame was supported by arcade posts, it was framed in a manner similar to the existing spere truss (Fig. 4.23). To convert the arcade post/aisle tie framing to hammer-beam framing is not just a matter of arch-bracing the aisle tie and sawing off the post. Firstly it requires the removal of the aisle tie and its substitution with a more substantial timber, a hammer beam. The hammer beam then needs to be arch-braced, before a truncated arcade post can then be framed into the top of the new hammer beam, (rather than in the previous aisle-tie, arrangement, in which the tie was framed horizontally into the post). The hammer beam at Tiptofts, however, does not appear to be a later insertion. Crucially, and in contrast to the aisle tie in the spere truss, the hammer beam is framed in 'reversed assembly', *viz.* the beam is *below* the wall plate (see *Glossary*). If the hammer beam was a replacement of an aisle tie, then this would have left the above cusped principal short, by the thickness of the replaced tie. Yet, and with no evidence of patching, the principal extends fully to the external end of the hammer beam. Further, if the hammer post began life as an arcade post, evidence of aisle-tie pegging would be visible just above its juncture with the hammer beam. No evidence for such pegging exists. Finally, the way the carpenter handled the wall post framing also indicates that the central frame was originally intended to be of hammer-beam construction. Unlike the rest of the wall-post framing in the hall, the posts in the hammer-beam frame are not only more massive in dimension, but they are doubled (Fig. 4.24).[38] The carpenter evidently designed this framing to perform extra structural duty, duty placed upon it by the demands of the hammer-beam framing and its increased thrust. Taking the above structural details into

[36] J. A. Middleton, 'On a Thirteenth-century Oak Hall at Tiptofts Manor, in Essex', *Archaeologia* 52 (1890), 647-50; RCHME, *Essex* (1916), Vol. I, p. 351.

[37] The following comments are based on unpublished drawings supplied to me by John Walker.

[38] Walker (2008), 8. These wall posts are called 'buttress-like' by Stenning, in Walker (ed.) (2011), 36.

account then, the hammer-beam central frame appears to be an original feature of Tiptofts's hall.

PILGRIMS' HALL

If Tiptofts is placed to the late 1320s, then two candidates for earliest hammer-beam remain. Pilgrims' Hall has been well-studied, most authoritatively by John Crook, and little can be added to his comprehensive 1991 study. The tree-ring date is precise, of 1310/11, but one anomaly may suggest that the actual construction was delayed after felling until the 1330s. In that decade a '*nova grangia*' ('new grange') was constructed in the precincts of Winchester Cathedral, and substantial accounts of 1334-5 relating to the construction of the grange remain.[39] The roof covering especially features in these accounts. 'Lathes' and 'lathnails' were bought to install the 94,000 roofing slates ordered by John of Merlawe, which, according to Crook, 'would suffice to roof the entire medieval building.'[40] One assumes 'the medieval building' Crook refers to here is the Pilgrims' Hall, although in discussing these accounts in relation to Pilgrims Hall, Crook is uncharacteristically vague.[41]

Is this *nova grangia* the same building as the Pilgrims' Hall? A large amount of slate fragments were found in the 1950s when the floor of the hall was lowered to its original level, leading contemporary investigators to conclude that the hall *was* the *grangia* built at the time of the accounts, but Crook in 1991 was initially noncommittal, then dismissive.[42] Anthony Emery in his monograph on Dartington Hall thought the

---

[39] *The Compotus Rolls of the Obedientiaries of St. Swithun's Priory,* ed. G. W. Kitchin (London, 1892), 230.

[40] Crook, 'The Pilgrims' Hall, Winchester', *Proc. Hants. Field Club Arch. Soc.*, 38 (1982), 96.

[41] Crook (1982), 96; Crook (1991), 143

[42] In their annual review of archaeological progress made in 1956, D. M. Wilson and John G. Hurst noted the following regarding Pilgrims' Hall: 'Three bays of this building … have been repaired … It is considered by the architect to be probably a grange or *bâtiment administratif,* in view of the details of its plan and the recorded provision of a large number of slates for that purpose in 1325/6 [*sic*, the date of the accounts is 1334-5] (G. W. Kitchen, *Winchester Cathedral Records* 1325/6) [this citation is untraceable], when it would appear to have been built. Excavations undertaken during the repairs have revealed that it originally had a slate-covered roof…', 'Medieval Britain in 1956', *Medieval Archaeology* 1 (1957), p. 152. Crook (1991), 143, 155.

Pilgrims' Hall and the grange identical. For Emery, probably relying on Wood (1965), and Wilson and Hurst (1957), the roofing slates purchased in 1334/5 were for the completion of the Pilgrims' Hall (although, compounding an error of Hurst who dated the accounts to a decade earlier, he states that the Pilgrims' Hall was constructed in 1325-6).[43] If Wilson and Hurst and Emery are correct, then the Pilgrims' Hall and its hammer-beam roof were completed in the fourth decade of the fourteenth-century.

Two factors weigh against this contention. Firstly, it would imply that the timber was felled, then stored, and used some twenty-five years later, a process contrary to known medieval carpentry practice of using green timber. Secondly, it would also show substantial and unusual forward planning on the part of the short-lived patrons who consequently would be tying up of resources for decades. If the *nova grangia* is the same building as Pilgrims' Hall, in itself a supposition, then the ordering of the slates twenty-five years after the timbers were available may, however, be explained. An early replacement of the original, perhaps thatch, covering of the still new grange may have been necessary due to defects. Such a modification is indirectly substantiated by the 1334-5 accounts, in which no heavy structural timbers are listed as being purchased. On balance, therefore, the purchase of roofing *covering* materials in the 1330s, while remaining a notandum, ought not to alter our understanding of the Pilgrims' Hall as a structure of 1310-11.

THE BISHOP'S KITCHEN

If the Pilgrims hall is a well-studied structure, by contrast the final candidate for earliest hammer-beam, the Bishop's Kitchen, has drawn less academic interest. Existing accounts are mainly descriptive, but all describe the unique framing of the kitchen, in which four, two-way, corbelled brackets support the upper faming of the square-plan kitchen (Fig.

[43] Anthony Emery, *Dartington Hall* (Oxford: The Clarendon Press, 1970), 138; Wood, 295, 315, 324; Wilson and Hurst, 152.

4.25 & Figs. 2.14 & 2.15).[44] The intention is clear: to de-clutter the circulation space of a busy kitchen by the removal of intrusive posts. As far as is known, this method remains unique. Other, later, solutions included stone vaulting, as found in the Abbot's Kitchen, Glastonbury (mid-fourteenth century) and the kitchen of the Cathedral Priory, Durham (1366-71); using large-section tie-beams to bridge the space: Gainsborough Old Hall, Lincolnshire (1462-70; fig. 4.26); and carpentering an arch-braced structure: Stanton Harcourt Manor, Oxfordshire (1485; fig. 4.27). Removal of posts to the end of reducing fire-risk was less of a motivation. Large section timbers are inherently difficult to ignite, and European Oak is very dense, which gives it a slow charring rate. Oak timbers retain their strength, and joints their integrity, even after periods of fire.[45] Medieval builders empirically knew this, and had no compunction to using heavy oak lintels over fireplaces, their clients habitually applying candles and tapers to them (Fig. 4.28).

It is surprising that published material on the Bishop's Kitchen is sparse, especially as, despite some contention in the 1980s, it now seems that the Kitchen may indeed be the earliest extant hammer-beam roof.[46] Admittedly, if we take the extreme, later, end of the Kitchen's dendrochronological parameters, Pilgrims' Hall would be the earlier structure, but documentary sources, allied with a comparison with another Chichester structure, St Mary's Hospital, suggest that a shift towards the opposite parameter would be more accurate.

Situated just half a mile away, St Mary's Hospital (Fig. 4.29), although an aisled structure of arcades and tie-beams, has a structural, as well as local, affinity to the square-plan Bishop's Kitchen. The kitchen's structure perhaps could be interpreted as aisled-derived, albeit of one bay, but the affinity is found in the mundane details of scantling and strutting. Previous scholars have noted the similarities in scantling in the two structures, and evident also are similarities in the way those scantlings are framed

[44] The most detailed description is in the VCH *Sussex*, Vol. III, (1935), 147-153. Brief accounts are in Munby 'Thirteenth-century Carpentry in Chichester', *Archaeological. J.*, 142, (1985), and Crook (1991).

[45] Peter Ross et al, *Green Oak in Construction* (High Wycombe: Trada, 2007), 34, 42.

[46] For earlier contention surrounding the date of the Pilgrims' Hall, see a superseded entry for the structure on the DDB at <http://archaeologydataservice.ac.uk/archives/> accessed 30/6/2012.

together (Fig. 4.30 & 4.31).[47] Double strutting, and cross-bracing in the spandrels formed by the strutting (a brief structural episode in English carpentry reminiscent of Villard's bridge), are found in both structures, as are the horizontal corner ties at arcade plate level.[48] Measured from drawings, the pitches of the two roofs are identical at 54°. So, while not conclusive, visual similarity and framing details indicate that the two structures may have been framed by the same carpenter. From documentary evidence, it seems certain that St Mary's Hospital was constructed in 1290 or shortly thereafter.[49] If the kitchen is by the same carpenters, it would shift the hammer-beam there to the earlier end of the tree-ring parameters. Carpentered, then, in the final decade of the thirteenth century, the Bishop's Kitchen would be the earliest extant hammer-beam structure.[50]

Certain scholars may object to this ranking. The kitchen has been called 'a highly evolved form of early English hammerbeam construction', a 'developed form' and 'an advanced piece of engineering.'[51] Crook thought it an 'eclectic structure' and 'not the prototype' of hammer-beam construction.[52] Yet the double strutting and the spandrel cross-bracing are typical of the period, and smack of over-engineering and a carpenter averse to risk. As for the structure being an 'advanced' construction, as we have seen, contemporary carpenters were fully conversant in constructing brackets - the component merely needed applying to the main timbers of a roof space. The remainder of the framing in the kitchen appears conventional.

---

[47] VCH *Sussex*, Vol. III, 151; Walter Horn and Earnest Born, *The Plan of St Gall* (Berkeley; London: University of California Press, 1979), Vol. I, 276; Vol. II, 92; John Fletcher, 'Medieval Timberwork at Ely', in Nicola Coldstream (ed.), *Medieval Art and Architecture at Ely Cathedral* (The British Archaeological Association, 1979), 63; Munby, (1985) 15-17.

[48] These components are found in 'William Russell's House' (9 Queen St.), Salisbury, dated to *c*. 1306; see Figs. 4.41 & 4.42.

[49] VCH *Sussex*, Vol. 2 (1973), 101.

[50] The title of Julian Munby's 1985 paper: 'Thirteenth-century Carpentry in Chichester', in which the kitchen is included, implies that he concluded the kitchen was of thirteenth-century date.

[51] Horn & Born (1979), Vol. I, 276; VCH *Sussex*, Vol. III, 151; Munby (1985), 15.

[52] Crook (1991), 150.

If the Bishop's Kitchen is indeed the first hammer-beam roof, then the shoots of hammer-beam construction sprout from more prosaic soil than previously thought.[53] Rather than stemming from shifting ecclesiastical or baronial tastes for the layout of a grand hall at the turn of the thirteenth century, the hammer-beam arose from quotidian domestic practicalities: the desire to de-clutter the bustling space of a kitchen. The possibility exists that carpenters then adopted a design of mundane rationale to suit the grander pretentions of an open hall.

More work still needs to be done on the two, somewhat neglected, Chichester structures. Ideal would be an archaeological analysis of the jointing techniques and tooling marks of the two buildings which may attest that the two buildings were indeed carpentered by the same hand (Fig. 4.32).[54] Carpenters, who through years of experience and practice have perfected trusted techniques, tend to stick with them.

The extent to which, if any, the Bishop's Kitchen influenced the design of the Pilgrims' Hall 40 miles to the west cannot be known. The Winchester structure seems more assured and advanced structurally, and to some extent, aesthetically. The chronological gap is only ten or fifteen years, but all of the double strutting and most of the spandrel cross-bracing has gone (Fig. 4.33).[55] Visually, the perspective is more ordered, less cluttered, and pure aesthetic intent is evident in the cambered tie beam. And yet the general form of the Chichester roof is more pleasing. The Winchester carpenter inserted arch braces of heavier section. Perhaps he thought the extra sectional timber would compensate for the lack of spandrel bracing, but these heavy timbers lend the roof a somewhat squat, cumbersome appearance. In contrast, the proportions of the scantling at Chichester seem more apt. Indeed squatness is avoided at Chichester, and the form is more elegant. The hammer posts reach higher into the roof space, aided nor only by a

[53] See J. T. Smith (1958), 120-124, for the motivation and methods for removing arcade posts.

[54] The exploded drawing of the post to arcade plate framing is in Horn and Born, *St Gall* (1979) Vol. II, 114; I am not aware of any drawings of similar detail of the Bishop's Kitchen.

[55] The remaining spandrel cross-braces are between arcade post and tie beam.

steeper pitch, but by a greater ingression of the hammer beam.[56] A consequence of this design is that, compared to its Winchester counterpart, the Chichester trefoil is more defined and balanced.

The hammer-beam roof had thus been born, an adaption of time-honoured carpentry techniques found in structures as diverse as bridges and aisled halls. One would expect that this progressive and advantageous form of construction would have been seized on by anxious patrons eager to open the space of their seigneurial halls. Yet curiously, at least from the extant evidence, for almost a century hammer-beam the construction was virtually ignored. I now set out to chart that indifference, and explore reasons for the apathy.

INDIFFERENCE

In the eighty years following the construction of the innovative hammer-beam structures at Chichester and Winchester, apart from Tiptofts, only one further hammer-beam roof is known to have been carpentered in England. This is astonishing. In the cradle of the hammer-beam, Sussex and Hampshire, *no* other fourteenth-century hammer-beam roofs are known, and no hammer-beams exist of any century based on the construction techniques of the Chichester and Winchester examples. At the time of writing, in the whole of Hampshire no other medieval hammer-beam roofs are known to exist. The fifteenth-century roof in the north chapel at Fordingbridge Church, stated by both English Heritage and Pevsner to be a hammer-beam, is in fact an elaborately braced and ornamented tie-beam roof (Fig. 4.34).[57] Its recumbent angels probably foxed the investigators.

[56] The hammer beams projects some 2% further into the internal space at Chichester than its counterpart at Winchester - measured from drawings in Crook (1991); Munby (1985), 14; and Emery, 238. Measured from Crook (1991), pp. 142, 151, the hammer beam at Chichester extends almost 25% into the internal space; the Winchester hammer beams almost 23%. The later Westminster Hall is the paradigm of the hammer-beam roof, and there the hammer beams project into the internal space by a little over 26%.

[57] *NHLE*; Pevsner & David Lloyd, *Hampshire and the Isle of Wight* (1979).

Fifteenth-century Sussex fares only a little better. Three medieval hammer-beams are known, all in halls: Imberhorne, East Grinstead (1428d); Great Dixter, Northiam (1465-75); and a minor example in Chateaubriand, Burwash (*c.* 1415).[58] None of these structures emulate the aisle-derived framing of the early hammer-beams. The only somewhat baffling conclusion to reach, then, is that in fourteenth-century southern England, the Chichester and Winchester hammer-beams had absolutely no influence.

Not that there was a dearth of building activity in south central England in the fourteenth century. Substantial halls were being built, but hammer-beam construction was spurned, patrons electing to remain in the tradition of tie-beam and crown-post roofs, as at Burghclere Manor, 1328/9d, and Tudor House, 1333d, East Meon (both Hampshire). Even the hall of the residence built for the Bishop of Winchester, William of Wykeham in 1395-97 at East Meon, with its span of 26ft (7.93m) relied on this conservative mode of construction (Fig. 4.35).[59] Artless cruck construction was still employed in some halls, and where a more progressive form of construction was chosen, the arcade post-eliminating base-cruck was favoured, not the hammer-beam. Indeed, between 1311 and 1393 more securely dated base-crucks were carpentered in Hampshire alone than hammer-beams in the whole of England.[60]

From the extant evidence then, puzzling is John Crook's reference to 'the prestige hammer-beam roofs enjoyed in the fourteenth century', and Horn & Born's comment that following the construction of the Bishop's Kitchen, 'English hammerbeam construction ... [was] very fashionable shortly thereafter.'[61] The polar opposite appears to have been true: fourteenth-century patrons rejected the hammer-beam. If the hammer-

---

[58] J. Clarke, 'An Early Vernacular Hammer-beam Structure: Imberhorne Farm Cottages, East Grinstead, West Sussex', *Vernacular Architecture* 36 (2005), pp. 32-40. Great Dixter: Wood (1965), 34, 315. David Martin, 'Chateaubriand, Burwash', *Sussex Archaeological Collections*, 112, (1974), pp. 21-27. It is debateable anyway whether Chateaubriand's single aisle qualifies as genuine hammer-beam construction. The hammer beam does not extend from a wall plate, but from conjectured framing at a midpoint on a wall post. See fig. 2 in Martin, 24.

[59] For the roof of Bishop Wykeham's house see Edward Roberts, 'William of Wykeham's House at East Meon, Hants', *Archaeol. J.* 150 (1993), 464-72. The building is now known as 'The Court House.'

[60] Fourteenth-century Hampshire base-crucks: Binsted, West Court, hall, 1314 – 1315d. Warnford, Riversdown, hall 1327d. Froxfield, The Hall, Trees Cottage, 1359d.

[61] Crook (1991), 152; Horn & Born (1979) Vol. II, 276.

beam roof was the prestigious fourteenth-century architectural object of desire, then why did not the architecturally literate Wykeham demand it for his new residence at East Meon?[62] It seems that the bishop had difficulty sourcing the 32 feet (9.75m) long tie beams which bridged his hall (Fig. 4.35).[63] Surely Wykeham, the Bishop of Winchester, a man who broke bread with Hugh Herland, would have known the hammer-beam roof in the precincts of his Cathedral. Yet he rejected hammer-beam construction, a method that inherently uses shorter, more conveniently sourced timbers. Other prestigious fourteenth-century halls, at Penshurst Place, Kent (*c.* 1341) (Fig. 4.36), Berkeley Castle, Gloucestershire (*c.* 1340-60), and the Guesten Hall, Worcester, (*c.* 1320), again all had substantial spans for which hammer-beam construction might have been thought ideal.[64] Yet for their wealthy patrons it was the arch-braced collar form which was their display roof of choice. Perhaps the hammer-beam was so bound to aisled construction, it occurred to neither carpenter or patron that the construction might assist a double-framed arch-braced roof.

BALLE'S PLACE

Before exploring further the reasons which lay behind the above indifference to hammer-beam roofs, the lone example of mid-fourteenth century hammer-beam construction in England ought to be considered. The merchant John Balle had his eponymous three-bay hall built in Salisbury between 1370 and 1385, and ostensibly the structure of his hammer-beam roof is analogous to the two earlier hall examples at

[62] Wykeham (1324-1404) was Clerk of the royal building works for Edward III; he founded Winchester College and New College Oxford and later oversaw work on the nave of Winchester Cathedral. He entertained craftsmen as dinner guests, most notably the King's Mason Henry Yevele (*fl.* 1353-1400), the master mason William Wynford (*fl.* 1360-1405), and the King's Carpenter, Hugh Herland. See relevant entries for the individual craftsmen in *EMA.*

[63] Roberts, 464.

[64] The span of 39 feet (11.9m) at Penshurst Place is unusually wide for the mid-fourteenth century; Guesten Hall span: 34ft 3in (10.44m). The span of the Pilgrims' Hall is a little over 30 feet (9.2m). The Guesten Hall is commonly dated to *c.* 1320 (*NHLE*), but see VCH *Worcestershire*, Vol. 4 (1924), 395, and J. T. Smith (1970), 260, for suggested later C14 dates.

Winchester and Wimbish (Fig. 4.37).[65] With jowled hammer-posts and square-set arcade plates, heavy raked struts between hammer beam and hammer post, the hall is clearly of aisle-derived construction. Canted hammer beams, a feature of two of the predecessors support those hammer posts, and, like Tiptofts, a crown-post roof surmounts the collar beam. Yet in a significant structural detail, Balle's Place is unique.

The hammer braces extend beyond the terminations of the hammer beams, to meet directly the upper arch braces which terminate, unusually, beyond the lower end of the hammer posts. This unique structure lends a unique form to the roof. The trefoil is thus allowed to flow, uninterrupted by protruding hammer beams, smoothly through the transverse frame. At 28%, the cusps formed by this unique framing extend into the internal space further than any previously constructed hammer-beam. If the line of the lower arch-braces is continued (the lower portions have been lost), then the composition was as balanced vertically as horizontally. As reconstructed, the vertical distance from corbel to point of cusp is identical to that from the cusp to the apex of the trefoil.[66] This roof was designed by a carpenter with a sense of proportion. The following are also equidistant: from apex of roof to top of collar beam; from soffit of collar beam to mid-point of hammer beam; from midpoint of hammer beam to base of (surmised) lower arch brace. The result is a clearly defined, dominant trefoil of balanced proportion. At his Salisbury residence, John Balle and his carpenter were in the pursuit of form over structure. Indeed, structure is to some extent compromised, especially at the end of the hammer beams where the arch braces have no abutments, and appear to be relying only on the pegging to the hammer beam to withstand structural forces.

A span of 21ft 6in (6.55m) did not demand that John Balle roof his hall with a hammer-beam in order to preclude arcade posts. A prosaic common rafter roof would have excluded the weather; a conventional crown-post roof would have adhered to contemporary mainstream predilections for display roofs. Yet Balle, perhaps

---

[65] The best account of this structure is in Helen Bonney, '"Balle's Place", Salisbury: a 14th Century Merchant's House', *Wiltshire Archaeological Magazine* 59 (1964), 155-67.

[66] See illustration in Emery, 239.

apprehending the formal potential of the hammer-beam, and an imaginative carpenter able to adapt hammer-beam construction to perfect that form, created a structure of subtle visual sophistication. Left to rot in a municipal yard, John Balle's hammer-beam, alas, is no more.[67]

FOURTEENTH-CENTURY HAMMER-BEAMS: SIMILARITIES, DISPARITIES AND DEARTH.

The fourteenth-century hammer-beam roofs hitherto discussed are précised in the table below.

Table 4.2.[68]

BUILDING	DATE	SPAN	PITCH	HAMMER-BEAM PROJECTION	WALLS
Bishop's Kitchen	*c.* 1300	34' 6" (10.52m)	54°	25%	Masonry
Pilgrims' Hall	1310/11	30' (9.14m)	49°	23%	Masonry
Tiptofts	*c.* 1325	28' (8.53m)	54°	19%	Timber-framed
Balle's Place	*c.* 1370-85	21' 6" (6.55m)	53°	28%	Masonry

To avoid repetition, only limited comment will be made about the similarities and differences in these few structures. Firstly, only two of the structures, Tiptofts and Pilgrims' Hall, are analogous. The Bishop's Kitchen, with its two-way mitred hammer beam construction is unique. Equally unique is the lower framing of the arch braces at Balle's Place. Both Pilgrims' Hall and Tiptofts are substantial halls where hammer-beam construction may have been thought desirable, if not essential, but neither of these, what the taxonomical purists would call 'true' hammer-beams, appeared to have spawned any

[67] Personal communication with conservation architect Mr Gerald Steer. Balle's Place was demolished in 1962 and the frame was put away in store for possible re-use. In the 1980s, Mr Steer adopted what were left of the timbers, which were in 'a terrible state.' Only two 'queen posts' (hammer posts) were salvageable, and those are now propping up a floor in a seventeenth-century house in Salisbury.

[68] Sources for measurements: the span for the Bishops Kitchen is the author's. The remainder of the measurements for the kitchen and the Pilgrims' Hall are taken from Crook (1991). For Tiptofts, RCHME *Essex,* Vol. I, (1916), p. 351-352, and Walker (2008) *passim*. For Balle's Place, Bonney, 156-7.

progeny. Indeed, no discernible trends or structural evolution can be traced in the above, of necessity limited, list. What could account for the stillbirth of this advantageous, both structurally and visually, construction?

Of note is that three of the four structures possess masonry walls. Hammer-beam construction functions to transform any downward forces, which previously travelled down the arcade post, into diagonal forces which are transmitted via arch brace and wall post to the wall. Masonry walls are able to be buttressed in order to accommodate these increased forces.[69] Timber-framed walls might be propped, but the result would be ugly, redolent of remedial measures. Further, the props would be prone to rot at the base, and a larger, possibly unfeasible, ground plan would be created. Tiptofts is unique in all fourteenth-century hammer-beam construction in having timber-framed walls. Indeed, the overwhelming majority of later medieval hammer-beam roofs have walls of masonry. Medieval carpenters evidently thought hammer-beam construction not suited to walls of timber-framed construction, and in the atypical example of Tiptofts, as we have seen, the carpenter took trouble to ensure the stability of his walls. Perhaps this fact alone helps to explain the dearth of fourteenth century hammer-beam roofs. In a society in which most buildings were of timber, here was a mode of construction which demanded the massive stability of masonry walls. Yet even that answer is of only limited satisfaction, for as we have seen, even the patrons of prestigious masonry-walled buildings rejected the hammer-beam roof. The technology was in place; the demand for bridging substantial spans with display roofs existed, but hammer-beam construction just did not take root.

Indifference towards the hammer-beam may be explained by their visual appeal, or rather, lack of it. The hammer-beam at Pilgrims' Hall, perhaps seen by many Pilgrims visiting the shrine of St Swithun, while structurally impressive, did not inspire emulation. Perhaps the trefoil is clumsily handled, resulting in an ill-defined and

[69] The masonry buttresses of Westminster Hall were improved and added to in readiness for its new hammer-beam roof in the 1390s, Christopher Thomas et al, *The Royal Palace, Abbey and Town of Westminster on Thorney Island* (London: Museum of London Archaeology Service, 2006), 101; Dorian Gerhold, *Westminster Hall: Nine Hundred Years of History* (London: James & James, 1999), 17, 21.

unbalanced form. Perhaps the timbers are too massive, and that, combined with the relatively low springing points of the roof, lends the structure a lowering, oppressive quality. Contrast that with the buoyancy and airiness of Penshurst Place. The tie beams of Bishop Wykeham's roof may be equally massive (Fig. 4.35), but only two occupy the internal space, and the upper timbers of the roof are of lighter scantling, and as we have seen, crown-post construction was established and popular. The effect in Wykeham's house is again open and lofty.

Perhaps the construction of the Pilgrims' Hall was just too explicit. In contrast to modern predilections, the medieval mind had a penchant for visual deception and architectural subterfuge. Thus, timber masquerades as a stone vault (numerous examples), or even an entire 'stone' structure (north porch of Boxford Church, Suffolk; Figs 4.38 & 4.39); a giant timber lantern appears to be held up by the slenderest of ribs (Ely), the timber roof of a great hall appears to be supported by complex hammer-beam framing (Eltham Palace). I introduce a theme here which will be dealt with in more detail in my chapter on the structure of Westminster Hall, but perhaps the overt structure of the Pilgrims' Hall simply lacked mystery.

Rationalistic straws are being grasped at here because the dearth of fourteenth century hammer-beams is genuinely puzzling, with no evidence to explain the lack. Some patrons evidently wanted the trefoil to infuse the longitudinal vistas of their halls, and their carpenters framed various superfluous and elaborate structural components to supply that vista. But again, the hammer-beam roof, which intrinsically provides the trefoil, was not chosen to create this aesthetic. Such trefoil framing, as at Upton Court, Berkshire (1319-20d), and William Russell's House in Salisbury (*c.* 1306), was in the service of tie-beam roofs, and had nothing to do with hammer-beam function of managing lateral forces in an untied open roof (Figs. 4.40 & 4.41).[70] As such framing was fulfilling a less demanding structural role, structure and form could be refined. The arch braces at Upton, for example, terminate well short of the hammer beam ends. Scantlings

[70] Another example of such framing is at 'Gobions' Great Bardwell, Essex, late fourteenth-century, discussed and illustrated in *EHC*, 178; Walker (ed.) (2011), 35.

were lighter; the framing at William Russell's House is noticeably less massive than the coeval hammer-beam at Winchester (Fig. 4.42; *cf.* 4.33 & 3.16), and the 'hammer beams' at Upton are exceptionally thin. Structure became the servant of formal demands for a sharply defined cusp.

Thus, if the extant evidence from a wide range of medieval carpentry is representative, and there is no reason to think that hammer-beams were disproportionately targeted by later developers, for almost a century the hammer-beam roof was stillborn. Perhaps Pilgrims' Hall itself, its ponderous squatness seen by countless visitors, sounded the death knell of the fourteenth-century aisle-derived 'true' hammer-beam at the moment of its inception. Dully utilitarian and explicit in structure, the hammer-beam roof needed an extraordinary defibrillatory event to jolt it back into life. And such an event did occur, realised by the confluence of two lives, one a maniacal demi-god, the other a carpenter: Richard II and Hugh Herland.

Chapter 5

MEDIEVAL WESTMINSTER HALL

PART 1: WESTMINSTER HALL 1099-1393,

The dreadful hall by Rufus rais'd
For lofty Gothick Arches prais'd[1]

Before discussing the Westminster Hall roof as commissioned by Richard II and conceived and carpentered by Hugh Herland, it is instructive to review the previous history of the hall, both prior to Richard's reign and during his kingship. By doing so, the building's significance as a royal great chamber, the deep personal meaning it developed for Richard II, and his motives for its reconstruction will be illuminated.

The hall in which Richard II held court, and the constructional challenge which confronted Hugh Herland in 1393, was commissioned nearly three hundred years earlier (1097-99) by the Conqueror's son, William II (Rufus). Measuring some 240ft (75m) by nearly 69ft (21m), and with a height of over 40ft (12.2m) to the eaves, it was the largest royal hall in Europe, and continued to dwarf other royal halls well into the fourteenth century (Figs. 5.1-5.4).[2] Chroniclers grumbled that in addition to a bad harvest of 1097, misery was increased as labourers were conscripted to work on the massive new structure. *The Anglo Saxon Chronicle* reported that William's court did more harm in the shires 'than a raiding army', and that it was 'a very heavy year in all things ... both when tilling should be done and again when produce should be gathered in ... many shires whose work pertained to London were badly afflicted ... through work on the king's hall ... and many a

[1] Doggerel from Charles Mosley's engraving *The First Day of Term* (1738).
[2] *HKW*, 44, 45, 528; RCHM, *London,* Vol. 2*, West London* (1925), 121, 122.

man was afflicted with that.'[3] Taxes levied to pay for construction were so high that 'many men perished of want'.[4] Nonetheless, despite the hardships imposed on the populace for the building of the great hall, it seems the patron was little impressed by its scale. While inspecting his new hall with a retinue of minions marvelling at its size, Rufus observed that 'it was not half large enough', and that 'it would only be a bedroom in proportion to the palace he intended to build.'[5] Richard II, however, was evidently satisfied with its size, as, while radically changing the aesthetic, he did not enlarge the hall in plan.[6]

Given Rufus's uncompromising nature, the new hall at Westminster must have been the apogee of current architectural design and technology.[7] In the eleventh century Romanesque architects were increasingly exploiting the decorative potential of internal wall elevations. Dividing the space both horizontally and vertically, they began to incorporate three-dimensional elements – shafts, mouldings, string courses and arcades.[8] At Westminster, commencing at a string course at the vertical midpoint of the wall, the hall was encompassed by a continuous arcaded wall passage of Romanesque arches (Figs. 5.5-5.6). The arcade was formed by the repetition of one large arch and two smaller flanking arches. To the observer inside the hall, the larger arches framed the windows piercing the exterior of the gallery. Such internal arcaded galleries were a particular feature of high-status buildings in Normandy and England in the late eleventh and early twelfth centuries. Indeed, wall galleries are one of the most distinct and 'exciting features' of English Romanesque.[9] Since in contemporary art Heavenly Jerusalem was often

---

[3] *The Anglo-Saxon Chronicle*, ed. M Swanton (Everyman, 1996), 233, 234.

[4] Henry of Huntingdon, *The Chronicle of Henry of Huntingdon,* ed. and trans. Thomas Forester (Felinfach: Llanerch, 1991), 237; Hilary St George Saunders, *Westminster Hall* (London: Michael Joseph, 1951), 23??.

[5] Henry of Huntingdon, 238 and nt.; also, Roger of Wendover, *Flowers of History*, trans. J. A. Giles, Vol. I, pt. 2, 1066 - 1170 A.D (Felinfach: Llanerch, 1994), 443; Saunders, 23.

[6] See Geffrei Gaimar**,** *Estoire des Engleis,* ed. & trans. Ian Short (Oxford: Oxford University Press, 2009), 325, for a 'sumptuous and splendid feast' held by Rufus in the newly constructed hall in 1099.

[7] W. R. Lethaby, 'The Palace of Westminster in the Eleventh and Twelfth Centuries', *Archaeologia* LX, 1906, p. 132. See Appendix 2 for the character of William Rufus.

[8] Roger Stalley, *Early Medieval Architecture* (Oxford: OUP, 1999), 191.

[9] Stalley, 202. See also Eric Fernie, *The Architecture of Norman England* (Oxford: OUP, 2000), p. 270: the arcaded wall passage 'becomes a standard part of Norman repertoire; indeed, the variations on the theme can

depicted as an arcaded structure, perhaps secular patrons wanted to impart a flavour of divinity to their great halls.[10] Such arcaded fenestration was also typical of the great churches of the period, and an arrangement similar to Westminster, of windows and gallery of a large arch flanked by two smaller arches, was once the arrangement found in the clerestories throughout Winchester Cathedral (begun 1079), now remaining in the transepts (Fig. 5.7).[11]

In addition to the fenestration, the bays at Westminster were almost certainly further delineated by aisle arcades.[12] Not only was it the ubiquitous, fashionable design of the day for the larger hall to be aisled, but carpenters were far from acquiring the technology to span such an enormous void with a clear span truss.[13] If the arcades consisted of stone piers, as might seem probable in such a grand building, Oakham Castle, Rutland (1180-90) may provide a small-scale indication of the hall's arcading (Fig. 5.8). The naves of the great Norman cathedrals also serve to indicate the prevailing general style and embellishment of any arcading, and, with the contemporary fondness for central open fires in great halls and the need for the egress of smoke, it is unlikely Rufus's hall was vaulted.[14]

If the piers were of stone, however, evidence of their existence would likely have been found in the numerous archaeological excavations carried out at Westminster Hall. Such evidence is absent. If the aisle arcades were of timber, then the oldest surviving

---

be seen as the single most important contribution which Normandy made to the Romanesque style'; also, 254, 255. For a detailed discussion of the development of Norman wall passages and clerestories see, L. Hoey, 'The Design of Romanesque Clerestories with Wall Passages in Normandy and England', *Gesta* 28 (1989), 78-101.

[10] See Stalley, 197, for examples.

[11] See Alec Clifton-Taylor, *The Cathedrals of England* (London: Thames and Hudson, revised ed., 1986), 8, 208.

[12] *HKW*, 528.

[13] No archaeological evidence has been discovered to indicate the form of the original roof. Evidence for the existence arcade piers is absent, which has led some scholars, for example, Christopher Wilson, 'Rulers, Artificers and Shoppers: Richard II's Remodelling of Westminster Hall, 1393-99', in Gordon, Monnas & Elam (eds.), *The Regal Image of Richard II and the Wilton Diptych* (London: Harvey Miller, 1997), 43, to conclude that the hall was of clear span. Absence of evidence, however, is not evidence of absence. See Appendix 2, 'Rufus's Roof: Aisled or Clear Span?'; also M. W. Thompson, *The Medieval Hall* (Aldershot: Scolar Press, 1995), 26; Lethaby, 136.

[14] Examples of Norman cathedrals (start dates): St Albans, 1077; Durham, 1089; Chichester, nave, 1114; Peterborough, Nave, 1118; Ely, nave, *c*. 1120. Also St John's Chapel, the Tower of London, c. 1078**.** I follow Eric Fernie in designating 'Norman' the period between 1066-1154, (2000), 317

portions of the timber-framed halls at Leicester Castle (*c.* 1150d) and the Bishop's Palace, Hereford (1179d), provide clues to the carpentry and detailing of such prestigious timber halls (Figs. 5.9-5.12). At Hereford, the aisle posts feature engaged shafts which rise from moulded, flared, bell-like bases through scalloped capitals and square abaci to support an arcade of moulded Romanesque arches with an intermittent nailhead motif. Romanesque arcades were present also at Leicester (the building has been much altered over the centuries). The remains of a few aisle posts (and possibly a collar beam) are all that remain at Leicester, and although square and plainer with simple stopped chamfers, these too feature scalloped capitals.[15] The roofs of these structures – the timberwork that supports the roof covering in contrast to the arcade carpentry – are later, and the nature of Rufus's roof at Westminster is unknown. Even in such a high status building it is likely to have been the roof carpentry typical of the period: functional and prosaic – oblivious to aesthetic potential.[16]

THEATRE OF KINGSHIP: THE HALL OF WILLIAM RUFUS

If the form of Rufus's Great Hall was that of a typical medieval hall writ large, then its function was of corresponding scale. Lesser aristocratic and manorial halls functioned throughout the middle ages as a transitional area between public and private space. Here the lord feasted, granted audiences, dealt with manorial business and dispensed justice, applying the law to a range of offences, from minor misdemeanours through to capital offences. In short, the hall was the arena in which the magnate held court.[17] As such, the

[15] *EHC*, 39-41; John Blair, 'The 12th-Century Bishop's Palace at Hereford', *Medieval Archaeology* 31 (1987), pp. 59-72; S. R. Jones and J. T. Smith, 'The Great Hall of the Bishop's Palace at Hereford', *Medieval Archaeology* 4 (1960), pp. 69-80; Alcock, N. W; Buckley, R. J., 'Leicester Castle: The Great Hall', *Medieval Archaeology* 31 (1987), pp. 73-79, also pl. V B; Walter Horn, 'The Potential and Limitations of Radiocarbon Dating in the Middle Ages: The Art Historians View', in Rainer Berger (ed.) *Scientific Methods in Medieval Archaeology* (Berkeley Ca.: University of California Press, 1970), pp. 56-66.

[16] See Chapter 7 of this thesis for the transformation of English carpentry from the late thirteenth-century onwards as patrons and carpenters realised the ornamental potential of monumental carpentry.

[17] M. W. Barley, *Houses and History* (London: Faber and Faber, 1986), 128; Jane Grenville, *Medieval Housing* (London: Leicester University press, 1997), 66.

hall was an expression of hierarchy. It was the dominant structure of any building complex, and it possessed the grandest and most imposing interior that the commonality would regularly see. It was an interior designed to evoke awe and trepidation, and one can only imagine the thoughts of a hovel-dwelling villein as he was led into the great hall to answer a charge or to submit a plea.

The royal hall at Westminster served all the above functions but on a colossal scale (Fig. 5.13). When the king was in residence, feasts were held regularly, but the most lavish were those held to celebrate coronations. Immediately after his coronation in the Abbey, a new king would process with pomp the short distance to the hall for his kingship to be then endorsed in profligate style. The chronicler Henry Knighton recorded the provisions acquired for the banquet following the coronation of Edward I in 1274: 440 oxen and cows, 430 sheep, 450 pigs, 16 fat boars, 278 flitches of bacon, and 22,460 capons and other poultry. Indigestion remedies are not among the items on Knighton's list. As usual on these occasions, the city conduits were reported as flowing with a liquid more tempting than water: wine.[18] Even allowing for exaggeration, Knighton, then, clearly wanted to convey a grand demonstration of regal munificence. Westminster Hall banquets welcomed magnates from the Shires, received foreign dignitaries, celebrated strategic betrothals; occasionally, they were even held for the London poor.[19] No doubt, as a boy, Richard II heard tales of the magnificent banquet held in 1337 to celebrate the newly conferred dukedom of his father Edward, the future Black Prince.[20]

If Westminster Hall functioned as an arena for the celebration of kingship, once the tables were cleared and the floor was swept, the hall assumed a more routine function as the centre of the administration of that kingship.[21] From early in the twelfth century,

[18] *Knighton's Chronicle, 1337-1396*, ed. G. H. Martin (Oxford: Oxford University Press, 1995), 546; Saunders, 47.
[19] Knighton, 152; Cooper, 187; Saunders, 29-70 *passim.* See Christopher Wilson, 'Rulers, Artificers and Shoppers: Richard II's Remodelling of Westminster Hall, 1393-99', in Gordon, Monnas & Elam (eds.), 1997, 34, for the king's role as 'feeder'of his people as well as leader.
[20] Saunders, 65. Edward was granted the Duchy of Cornwall at this time; Barbara Emerson, *The Black Prince* (London: Weidenfeld & Nicholson, 1976), 11.
[21] It should be remembered that for much of the Middle Ages the king and his court were itinerant. The following applies mainly to when the king was in residence at Westminster.

notwithstanding the peripatetic nature of the royal court, Rufus's hall had often been used as the meeting place of the Great Councils of lords and prelates.[22] Those meetings of the Great Council, consisting of the king and his advisors, continued through the decades, and on many occasions Westminster Hall was to be the scene of major constitutional events. It was there that in 1258, the hall rattling with the clamour of armed men, nobles, including Simon de Montfort, made the demands of Henry III which eventually led to the institution of Parliament.[23] As the organ of government now known as Parliament gradually took form, Westminster Hall became the place where a full complement of that assembly often sat. Thus, in Westminster Hall policy was made; momentous, legal, fiscal, strategic and revolutionary decisions were debated and publicly proclaimed. According to Jean Froissart, in that very chamber packed with prelates and nobles, the regally attired Edward III, 'seated like a pontiff' with crown and sceptre, declared the war that would later become known as 'The Hundred Years War'.[24] On 30 September 1399, Westminster Hall became the scene of a revolution, as the notice of Richard II's deposition was read to a hall packed with nobles and prelates.[25] Naturally, as Westminster Hall became central to royal policy making and the dissemination of those policies, it was also assuming an important role as the venue for legal redress.[26]

---

[22] Cooper, 169, 188-189; Saunders, 25, 28. See Anthony Goodman, 'Richard II's Councils', in Goodman and James L. Gillespie (eds.) *Richard II The Art of Kingship* (Oxford: OUP, 1999), pp. 76-82, for the nature of the Great Councils in Richard II's time.

[23] Saunders, 42. J. R. Caldicott, *Simon de Montfort* (Cambridge: CUP, 1994), 52-54.

[24] Froissart is quoted In Saunders, 65. See also Dorian Gerhold, *Westminster Hall: Nine Hundred Years of History* (London: James & James, 1999), 14-15.

[25] Nigel Saul, *Richard II* (New Haven; London: Yale University Press, 1997), 422; Christopher Given-Wilson, *Chronicles of the Revolution, 1397-1400* (Manchester: Manchester University Press, 1993), 124-5, 171-72.

[26] This is not to argue that Westminster Hall was the chamber where the Great Councils and parliament always met when in Westminster. It appears that the preliminary proclamations of parliament were often made, and momentous decisions declared, in the great hall, but the business of parliament, unless it was a particularly large gathering, a 'full parliament', was often done in smaller rooms of the palace (*The Westminster Chronicle*, ed. & trans. L. C. Hector and Barbara F. Harvey (Oxford: Clarendon Press, 1982), 146, 174, henceforth: *WC*). Cooper suggests that during the reign of Henry III, these more intimate gatherings were held in the splendour of his 'King's', or 'Painted' Chamber (constructed 1232-36; Fig. 5.13), although some doubt may be cast on this suggestion as this was the king's private chamber containing his bed; see Ivy Cooper, 'Westminster Hall and the Meeting Places of Parliament in the Ancient Palace of Westminster'*, Journal of the British Archaeological Association*, 1938, p. 110. and *passim*; also Saunders, 63. Of the exact location of meetings, unless the source precisely states, for example, *aulum Westmonasterii* (Knighton 413, 548), it is difficult to be certain. 'Probably'

An account from 1234 tells of Henry III hearing a charge in Westminster Hall against seven Jews who were accused of kidnapping a small boy with the intent of crucifying him at Passover.[27] By the ascension of Edward I in 1272, the courts of law, rather than following the perambulations of the king's court around the country, seem to have been taking up residence in Westminster Hall.[28] Three of the four royal courts appropriated corners of the hall. The Kings Bench, dealing with all matters directly connected with the sovereign, or deemed worthy of his personal judgment, was located, as was apt, at the south 'high' end of the hall, in the east corner. In the south-west corner sat the Court of the Chancery, the seat of the Lord Chancellor and the Master of the Rolls, dealing with appeals, mitigating harsh applications of common law, and refining its deficiencies.[29] Reflecting the hierarchical, if simple, ordering of space of the medieval hall, the Court of the Common Pleas, dealing with suits between private citizens, was located in the lower half of the hall against the west wall. It is entirely possible that the structure of the hall affected the positioning of these courts, each court perhaps occupying a bay or bays delineated by the arcade posts. For six centuries, Westminster Hall was to become the permanent home of the courts. A satirical eighteenth-century engraving of Richard II's hall depicts these courts still in their positions, and incidentally shows how

---

and 'perhaps' are words that occur in secondary literature when discussing the venue for parliamentary and council meetings during this period. (Saunders, 56, 60, 63; G. L. Harriss, 'The Formation of Parliament', in R. G. Davies, J. H. Denton (eds.), *The English Parliament in the Middle Ages* (Manchester: Manchester University Press, 1981), 37; Christopher Jones, *The Great Palace: The Story of Parliament* (London: BBC, 1983), 14. Also, the king's court continued to be itinerant during the Middle Ages, and the Great Councils and Parliaments met wherever he happened to be. In the fourteenth century, however, especially from 1338 onwards, Parliament almost always met in Westminster. In Richard's reign only parliaments of 1378 (Gloucester), 1380 (Northampton), 1384 (Salisbury), 1388 (Cambridge) and 1393 (Winchester) met away from Westminster. (*WC*, 66, 354; Thomas Walsingham, *The St Albans Chronicle: The Chronica Maiora of Thomas Walsingham*. Vol.1, 1376-1394, ed. John Taylor and Wendy R. Childs; trans. Leslie Watkiss (Oxford: Clarendon Press, 2002), 246, 248, 400, 857, 936. See also Gervase Rosser, *Medieval Westminster, 1200-1540* (Oxford: Clarendon Press, 1989), 36, 37.

[27] Saunders, 34. This was a common charge against the Jews in the Middle Ages; see also Saunders, 41, and *The Chronicle of Lanercost*, 1272-1346, trans. Sir Herbert Maxwell (Glasgow: James Maclehose, 1913), 6.

[28] John Stow, *Survey of London*, quoted in Saunders, 49, see also pp. 45, 64; Jones, 23- 25; See Cooper, 1936, pp. 193-220, for a discussion of the hall as the centre of justice; also *HKW*, 543-5; Rosser, 164.

[29] Saunders, 48. The roll of the Lord Chancellor has been described as, 'the King's conscience', Jones, 191.

the hall had become the centre of trade in both in learned books and more trivial items (Fig. 5.14).[30]

The King's Bench was occasionally called upon to pass judgement upon that most direct challenge to kingly power: treason.[31] One of the more famous victims of such justice was the Scottish nationalist William Wallace. His grisly fate pronounced in Westminster Hall following his trial in 1305 was designed as a display of royal might, and of the fate of those who counter it. The brutal sanction was not always required, however, and Westminster Hall was also the scene of shrewd and, at times, duplicitous diplomacy, as potential rebellions were defused by sagacious oratory - or downright lies.[32] Royal mercy could then be bestowed as the king saw fit. Following an outbreak of defiance in the reign of Edward II, penitent supplicants were granted mercy while prostrate at the feet of the Edward enthroned on the dais of the hall.[33]

Statesmanship and the prospect of being eviscerated at Tyburn were not always enough to quell incipient rebellion. The successful demands of Simon de Montfort and his armoured cohort in the hall have already been noted. Somewhat paradoxically, then, in its pre-Ricardian history Westminster Hall, the venue designed for the display of royal power, was also to witness scenes of royal impotence, manifest in events ranging from popular disgruntlement to revolution, including the first deposition of a king in English history.[34]

In January 1327 Westminster Hall was the backdrop to the tumultuous 'display of political theatre' that was the dethronement of Edward II.[35] The Parliament that forced his deposition began on the seventh, probably in a room adjacent to the hall, but within

---

[30] Such stalls apparently existed in the reign of Edward III, Cooper (1936), 206

[31] See Saunders, 51, 52.

[32] Saunders, 39.

[33] Gerhold, 14; Saunders, 57, 60; see also Seymour Phillips, *Edward II* (New Haven, Conn.; London: Yale University Press, 2010), 215-16.

[34] See Jones, 19, for a vivid account of revolt in 1253 with Westminster Hall as the backdrop. On pain of excommunication Henry III was forced to swear an oath to uphold the provisions of the Magna Carta; also Saunders, 40, 41.

[35] Ian Mortimer, *The Perfect King* (London: Vintage, 2008), 52.

earshot of the baying London malcontents who had filled the great hall in expectation.[36] The deposition then stalled in a week of politicking and argument. Finally, on 13 January, the *Pipewell Chronicle* reports (with some hyperbole) that, 'the archbishops and bishops, earls and barons, abbots and priors and all others from the cities and boroughs together with the whole commonality of the land' assembled again in Westminster Hall. The throng listened to the Archbishop of Canterbury as he preached a sermon on the theme of *Vox populi, vox Dei*. To cries of 'away with the king' and 'let it be done', the deposition of Edward II was decreed, and Edward's fourteen-year-old son, the future Edward III, was led into the great hall of the Palace of Westminster to receive the encomium of the people.[37]

Until the reign of Richard II such toppling of kingship was a unique event in England, and the most enduring image of Westminster Hall during the Middle Ages is still one of a very public theatre of kingly power. Coronation celebrations, extravagant receptions, prostrate magnates, knighthoods, declarations of war, declamatory speeches, the condemnation of traitors, all paint a picture of a chamber where the royal prerogative was very publicly confirmed, and one final example serves to sustain this point.

In 1357, the war with France was proceeding indifferently.[38] Then, at the battle of Poitiers, the English were not only victorious, but astoundingly a King of France, John II, was captured on his own soil.[39] The unprecedented trophy clearly had to be brought home, and the Black Prince and his captive landed at Plymouth on 5 May 1357. The slow ride north was a triumphal procession; the populace came out to gawp and celebrate, and everywhere the royal entourage were fêted.[40] On the twenty-fourth they reached the outskirts of London, and were met by an escort of city dignitaries splendidly enrobed.

---

[36] Philips, 524-531, discusses the events at Westminster; also Saunders. 61. Due to the lack of an official record of these events a precise chronology is impossible, May McKisack, *The Fourteenth Century 1307-1399* (Oxford: Clarendon press, 1959), 88, nt. 5.

[37] *Lanercost*, 257, 258; Mortimer, 52, 53; McKisack, 88-91. For the *Pipewell Chronicle*, see Antonia Gramsden, *Historical Writing in England* Vol. II *1307 to the Early Sixteenth Century* (London: Routledge & Kegan Paul Ltd., 1982), p. 4, nt. 13.

[38] McKisack, 137.

[39] Mortimer, 322; McKisack, 139, 140.

[40] Mortimer, 328.

The parade passed though streets strewn with rose petals and between houses bedecked in splendid hangings and martial paraphernalia, some displays mocking the captive. Girls suspended in cages scattered gold and silver leaves into their path. The streets were choked with celebrants – soldiers had to clear the way with spear butts – and every vantage point was packed with spectators craning to witness this unique event.[41] Again, the conduits flowed with wine.

And to where did this cortège proceed to pay homage to the king? Which edifice was judged most fit to express this triumph of English kingly power? King John was led to neither of the two major royal palaces at Windsor or Sheen, even though the party would have passed Sheen on the road into London from the West Country. He was not even led to the royal citadel of the Tower. The royal party was conducted to Westminster Hall, to the dais and a waiting Edward III enthroned in splendour.[42]

RICHARD II, KINGSHIP, AND THE HALL OF WILLIAM RUFUS.

'Grant that the glorious dignity of the royal hall may shine before the eyes of all with the greatest splendour of kingly power'[43]

Ascending to the throne at the age of ten, Richard II probably had little inkling of the regal history of the great hall of the Royal Palace of Westminster. As his reign unfolded, however, the hall was to take on a significance surpassing that which it had had for even his most illustrious and infamous of predecessors. His personal experience of this architectural articulation of kingly power may have begun with his attendance at the

[41] Froissart, *Chronicles*, trans. & ed. Geoffrey Brereton (Harmondsworth: Penguin, 1978), 141-43; John Cammidge, *The Black Prince: an Historical Pageant* (London: Eyre and Spottiswoode, 1943), 216-218.
[42] Mortimer, 328, 329; Saunders, 66.
[43] *Prospice*, a blessing prayer used during the coronation; translated and quoted in Wilson, 34.

opening of the Parliament of January 1377.[44] His most intense early encounter, however, with the hall was during his coronation day of 6 July 1377.[45]

It was the first coronation for over half a century, and London was packed with visitors from all corners of the kingdom eager to witness the spectacle, and such spectacle began and ended in Rufus's great hall. The boy, seated on the marble throne at the high end of the hall, awaited the prelates who were to conduct him into Westminster Abbey. A striped red carpet was unrolled through the length of the hall; it continued out through the door and across the road into the abbey. Clothed in garments of the purest white, Richard was then escorted to the ceremony by the complement of archbishops in full regalia. After his anointing, prayers were offered that not only called for Richard to be blessed, but also the great hall whence he was returning: 'Grant that the glorious dignity of the royal hall may shine before the eyes of all with the greatest splendour of kingly power and that it may seem to glow with the brightest rays and to glitter as if suffused by the illumination of the utmost brilliance.'[46] With such a blessing the hall attained the status of a sacred space.

Richard's return journey to the great hall, now as God's king, was less formal. On leaving the abbey, the magnitude of the occasion appears to have taken its toll on the boy, and in a moment of tenderness, Sir Simon Burley, Richard's guardian and tutor, his father's comrade in arms during the French campaigns, 'took the king up in his arms, attired as he was in his regalia', and carried the king high on his shoulders through the crowds and back into the hall. On the way a lucky spectator acquired a priceless souvenir. In the mêlée Richard lost one of his 'consecrated shoes', as worn by both Alfred the Great and Edward the Confessor during their coronations.[47]

---

[44] Saul, 21.

[45] *The St Albans Chronicle: The Chronica Maiora of Thomas Walsingham*. Vol.1, 1376-1394, ed. John Taylor and Wendy R. Childs; trans. Leslie Watkiss (Oxford: Clarendon Press, 2002), 141-149; Saul, 24-27. The record of the ceremony in Richard II's personal book *Liber Regalis* is the earliest detailed account of the English coronation ritual to survive.

[46] Wilson, 34.

[47] *WC*, 415-417; Walsingham, 152. For a brief biography of Burley see James L. Gillespie (ed.), *The Age of Richard II* (Stroud: Sutton, 1997), 117.

The impression that the pomp and majesty of the coronation day left on Richard can only be inferred. The day continued to be an overwhelming physical strain on the boy, since on occasion he had to retire to private chambers due to feeling faint. Probably Richard understood little of the symbolic particulars of the coronation ceremony. Nonetheless, the overwhelming majesty, the pomp, the divine symbolism, all with Richard as their cynosure, must have left an indelible impression.[48] And a further incident, bound to kingship, loyalty and dynastic right, occurred in Westminster Hall which also must have left a similar mark on the boy. During the coronation banquet, the King's Champion, Sir John Dymoke, mounted on a royal charger and clad in armour hand-picked from the royal armoury, rode into the hall and hurled down his gauntlet to challenge anyone who denied the prerogative of the boy-king. The challenge was called three times. It went unanswered, and the king presented his champion with a golden cup as reward.[49] In the light of subsequent events in that same hall, it was a moment of portentous irony, and one that perhaps Richard conjured up during constitutional agonies that were to come.

Inevitably, notwithstanding such splendid affirmation in Westminster Hall, during his minority Richard ruled in name only. A council of kinsman nobles governed England, the principle one of which was Richard's uncle, John of Gaunt. Westminster Hall continued in its quotidian role at the centre of administration, law and state feasting. Meanwhile, the fledgling king began to stretch his wings. His triumphant part in foiling the Peasants' Revolt in 1381 was a key moment in the assumption of his kingship.[50] As Wat Tyler lay dead at Smithfield, Richard is said to have told his mother Joan of Kent 'I have recovered today my heritage which was lost and the realm of England.'[51] In the

---

[48] Saul, 26; Patricia J. Eberle, 'Richard II and the Literary Arts', in Goodman & Gillespie (eds.), 1999, 234. Richard clearly remembered the incident of the lost shoe. In 1390 he had a new pair made to replace the odd shoe, *WC* 414, 416.

[49] Saul, 72.

[50] Anthony Tuck, 'Richard II (1367–1400)', *Oxford Dictionary of National Biography*, (Oxford University Press, 2004), online ed., Jan 2009, <www.oxforddnb.com> accessed 01 Aug 2012.

[51] Saunders, 73.

following years the young king grew more confident and assertive, and conflict with the council of nobles became inevitable.

Yet even at this early stage of his kingship Richard's popularity began to wane. As his great-grandfather Edward II, he had the misfortune to follow a popular, long-lived king, 'the perfect king', Edward III.[52] Even in the late 1370s the Commons was criticising his court for its profligate spending, and such censure was to plague Richard for the next decade. In that court, the newly confident Richard was choosing his own, often young, advisors and ministers, and upon his favourites he bestowed lavish privileges judged unmerited by his critics. Such critics concluded that the youthful courtiers were leading the king astray. England was, after all, still at war with France, and could ill afford, both financially and strategically, to be led by 'traitors, trouble-makers, sycophants, evil-willed useless gossipers and idlers.'[53] By 1386, chroniclers were reporting that the kingdom had been 'subverted by the ineptitude of your [Richard's] ministers, and wretchedly cast down and set at variance by feeble government, its fame thus impaired, and the memory of your person scandalously defamed.'[54]

If the restructuring of his court and the consequent direction of royal patronage was one reason for the increasing unpopularity of Richard in the early 1380s, then so was his perceived attitude to the war with France.[55] His father and grandfather had been warriors of renown. Yet under the aegis of Richard, during the 1380s the war with France was making little progress, and with talk of diplomatic approaches, he was being viewed as an appeaser. Richard did take the field, in the expedition to quash those perceived allies of France, the Scots, in the summer of 1385. It was an expedition intended to establish the eighteen-year-old king as a great strategist and warrior.[56] The campaign,

[52] Mortimer, 5-11; J. W. Sherbourne, 'Aspects of English Court Culture', in Scattergood and Sherbourne (eds.), *English Court Culture in the Later Middle Ages* (London: Duckworth, 1983), 5.

[53] Walsingham's later judgement of Richard's advisors, 848; see also the comments of the chronicler Adam of Usk, *The Chronicle of Adam of Usk*, ed. & trans. C. Given-Wilson (Oxford: Clarendon Press, 1997), 76.

[54] *WC*, 54; Knighton, 361, 358; Tuck, *DNB*; Saul, 437.

[55] Anthony Goodman, Introduction to Goodman & Gillespie (eds.), 3, 4.

[56] 'The kyng Richard with hoste went at his wyl / in to Scotland his corage to fulfyll', *The Chronicle of John Hardyng* (London: Printed for F. C. and J. Rivington *et al*., 1812), 340.

however, fizzled out and descended into an orgy of rape and pillage. The Scots had melted into the hills and forests, and with them any hopes of martial glory.[57]

By the autumn of that year, frustrations with the deficiencies of Richard's kingship crystalized into action. At Westminster, the Commons, in 'full parliament', so possibly in the great hall, demanded that measures be imposed to constrain Richard's extravagant court spending, for 'it was well known to be more to the king's credit, and, indeed, to his subjects' advantage, for him to live of his own than for him to be eternally fleecing them for the means of his subsistence and other necessities.'[58] To defuse the challenge, Richard agreed to some of the Commons' demands, but postponed his decision on others.[59] A compromise had been reached, but his kingship was on probation.

Circumvented by Richard and his Chancellor Michael de la Pole, a royal appointee and favourite, few of the reforms were ever implemented.[60] During the summer and autumn of 1386, however, under threat from an apparently imminent French invasion, Parliament finally lost patience with Richard and his court.[61] The request to Parliament by Chancellor de la Pole for a quadrupling of taxes to counter the invasion was met by a demand from the Commons for his immediate dismissal and a refusal to proceed with parliamentary business until that demand was met. At first Richard withdrew from Westminster, refusing to attend Parliament and accede to a demand that questioned his

---

[57] *WC*, 126-30; Knighton, 336; Walsingham writes that 'the scots … vied with each other in their haste to reach hiding places', 760; also Saul, 144, 145; *DNB*; James L. Gillespie, 'Richard II King of Battles', in Gillespie (ed.), 1997, 143, 144.

[58] *WC*, 146; Goodman, 'Introduction …' 7. Recent research has shown that Richard's household seems to have been twenty-per cent larger than that of Edward III; J. A. Tuck, 'Richard II's System of Patronage', in Du Boulay & Barron (eds.), *The Reign of Richard II* (London: University of London, 1971), 5, nt. 16.

[59] Saul, 147.

[60] Anthony Goodman, 'Richard II's Councils', in Goodman & Gillespie (eds.), 69.

[61] Walsingham, 792. During 1385-86 a French invasion seemed certain and imminent, often causing panic. Charles VI commissioned a huge wooden fortress which was built at Rouen. It was then dismantled and by the use of 72 ships transported to the coast. This prefabricated structure was intended for use in the siege of London; see Roland Bechmann, *Trees and Man: The Forest in the Middle Ages*, (New York: Paragon, 1990), 169. For further contemporary accounts see Edith Rickert, *Chaucer's World*, ed. Clair C. Olson and Martin D. Crow (New York: Columbia University Press, 1948), 297-305.

judgement and his right to appoint whomever he saw fit to high offices of state.[62] The magnates insisted on a crisis meeting, during which Richard's intransigence appears to have been tempered by mention of the fate of his great-grandfather Edward II. In November of that year Richard finally agreed to preside at what became known as the 'Wonderful Parliament.'[63]

How many of the proceedings of the 'full parliament' took place in the great hall is impossible to say, but by the end of that Parliament, with Richard presiding, his kingship was to be severely bridled, and he personally humiliated.[64] In what Nigel Saul calls, 'a delegation of Royal authority', but which, rather than a passive act on Richard's part, seems more a parliamentary and aristocratic coup d'état, Parliament appointed 'a great and continual council' to govern for a year.[65] The council was empowered to survey the king's estate and household and assess their condition, and Richard was forced to grant the council unprecedented powers to enter his household, seize any relevant documents and records, and to impose reforms as it saw fit.[66] Reforms were imposed and were effective: during the following year expenditure on the Kings wardrobe was reduced by nearly a third, from £1700 to £1200 in a year.[67]

The phrasing of the question put by Richard to a council of his judges in August of the following year regarding whether the actions of the Great Council were 'derogatory to the regality and prerogative of the lord king' seems understated.[68] By the time the 'Wonderful Parliament' had finished its work, his privacy had been violated, his spending severely reined back, and despite his statement that he would not dismiss 'so much as a scullion from his kitchen at parliament's request', he had been forced to dismiss close

[62] Knighton records that when asked to remove le Pole 'the king was greatly annoyed and told them to mind their own business', 354.
[63] Knighton, 360.
[64] *WC*, 174; Knighton, 368, 370.
[65] *WC*, 168; Saul, 161, 162.
[66] *WC*, 168, 170, 172; Adam of Usk writes that the purpose of the 1386 Parliament was 'to curb the lasciviousness and greed of his familiars and sycophants and… to reform the affairs of the realm', 8; Saul, 161, 164.
[67] Saul, 165; Knighton alleges that at the time of the Wonderful Parliament Richard 'was so much in debt that he could not otherwise pay what he owed and not meet his other commitments', 354.
[68] Knighton, 394, 396; Saul, 183.

friends and personal appointees from government.[69] In short, the King of England had been told he was inept at managing his own affairs and ruling the country. The Great Council even took control of those symbols of personal royal will, the Great and Privy seals. By the end of 1386 the Council controlled virtually all the instruments of government, and Richard was required to swear an oath to abide by its dictates.[70] Richard, God's anointed monarch, was again king in name only.

Richard spent most of the following year in the Shires away from Westminster trying to rally support, both martial and legal, for his return to Westminster at the end of the decreed period of Great Council's governance. Certain magnates, however, the so-called 'lords appellant', were still not satisfied with the restrictions placed on Richard.[71] Pursuing more power for themselves, they declared that Richard's privileged inner court was infested with traitors 'who haunted the king's presence', and that they were, 'eager to move as quickly as possible against these creatures so that we can save ourselves – indeed the entire kingdom – from treachery lurking unseen and the snares that spell death.'[72] By mid-November, with the spectre of civil war looming, the Appellants had assembled an armed force in London, and were demanding a meeting with Richard to present their indictments and obtain redress. Five of his favourites were to be accused of treason. Richard chose to meet this challenge in Westminster Hall.

According to Knighton, the hall was crowded, 'the whole place ... filled with lords and commons.' 'Bedecked in royal insignia' the king had to await the arrival of the rebels for almost two hours.[73] When they arrived the Appellants came in force, with 300 horse, and on dismounting, clanked fully armoured to the portal of the great hall. Nonetheless, the grand setting seemed to overawe the Appellants. Spectators packed the ancient hall. The Appellants were presented with a long walk before the crowd to the steps of the dais,

---

[69] Knighton, 354; Tuck, *DNB*.
[70] Saul, 162, 166.
[71] The five Appellants (accusers) were: Thomas of Woodstock Duke of Gloucester (Richard's uncle); Richard Fitzalan Earl of Arundel; Thomas Beauchamp Earl of Warwick; Henry Earl of Derby (Bolingbroke, Richard's cousin and later Henry IV); Thomas Mowbray Earl of Nottingham.
[72] *WC*, 210.
[73] Knighton, 413; Walsingham, 834.

upon which an enthroned Richard waited. The king, his sceptre in hand, was clad in regal finery of the utmost splendour, and was flanked by oversized, gilded and polychromed images of his forebears (Fig. 5.15). It was a Ricardian composition bellowing dynastic right.[74] In the doorway the Appellants prostrated themselves, and approaching the dais, they repeated the act of obeisance twice more.[75]

According to Walsingham, the encounter proceeded with the Appellants on their knees, and Richard, in deific manner, refused to speak to them directly, directing the Bishop of Ely to do so.[76] The king at first tried the emollient of statesmanship. He extolled his own mercy and patience, stating that he only forbore from destroying the rebels out of 'concern for their welfare', as, 'it is well known that our lord king has a great aversion to spilling blood.'[77] But later in this dynamic setting, with the crowd looking on, Richard's mood darkened. 'How dare ... by what presumption' had these lords, of whom Richard 'took no more account ... than the vilest scullion in my kitchen', entered this hall, wearing their swords in a place they ought not, to make such demands and accusations of their King? He roared 'if I had wished [my soldiers] would have rounded you up like cattle and slaughtered you.'[78] At some point gauntlets were thrown down and challenges to prove the accusations by ordeal by combat were issued. It was grand political theatre in the grandest of arenas: Westminster Hall.

Nevertheless, Richard's attempt to intimidate via the magnificent ancient setting and symbols of royal might and protocol did not deflect the Appellants from their revolutionary course. Implacably they put their case, and Richard knew he had neither the popular nor military support to thwart them. Finally, he assented to their requests, including the confinement of five of the principal 'traitors', intimate members of his court

---

[74] Richard commissioned thirteen over life-size stone figures of his ancestor kings in 1385; six, at 6 feet 8 inches (2.03 metres) in height, were to stand in specially constructed niches on the south wall, *HKW*, 528; *AC,* 515.

[75] *WC*, 212; Knighton, 414; Saunders, 74, 75.

[76] Walsingham, 834, 836.

[77] Walsingham, 834.

[78] Walsingham, 837,

chosen personally by him.[79] The charges of treason, with their grisly implications, were ordained to be heard in the Parliament for February 1388.[80] Richard's acquiescence, however, was a ploy. He was playing for time; time to allow one of his favourites, and one of the 'traitors', Robert de Vere, to escape and raise an army.

The king's strategy failed, and De Vere's troops were intercepted and destroyed by appellant forces en route to Richard's support. By December 1387 the Appellants controlled London and Richard had taken refuge in the Tower to await his fate.[81] There, he was confronted by the five lords. In the one-sided negotiations that followed, some chroniclers suggest that he even suffered the fate of his great-grandfather and was deposed for three days. A few days earlier, the appellant lords had already threatened to dethrone him because he had reneged on the promises made in Westminster Hall just a few weeks ago, and because he was still 'better pleased to be guided by the falsest of traitors ... to the enfeeblement of the kingdom.'[82] Nonetheless, Richard was restored to the throne - on condition that he 'henceforth submit himself to the control of the lords' - but only, it seems, because the appellants could not agree who should be his successor. As king, he was forced to perform the duty of reconfirming the Parliament at Westminster for 3 February 1388, in which the closest of his inner circle, including friends and allies from boyhood, would be tried for treason.

Saunders writes, plausibly, that major proceedings of this momentous Parliament took place in Westminster Hall.[83] Traditionally it would have opened and closed there,

---

[79] Michael de la Pole, Earl of Suffolk; Robert de Vere, Earl of Oxford; Nicholas Brembre, Mayor of London; Chief Justice Sir Robert Tresilian, and Alexander Neville, Archbishop of York.

[80] *WC*, 214.

[81] Knighton, 424.

[82] WC, 218, 228; Walsingham, 848.

[83] Saunders, 76. It should be noted that the pro-Appellant tract writer Thomas Favent (*fl*. 1388-1400) reports that the White Hall was used. He writes, however, that it was an assembly of the 'Great Parliament' of 'all of both estates' with 'a numerous throng', a 'mass of people filling the hall even to its corners,' in A. R. Myers, (ed.), *English Historical Documents 1327-1485,* Vol. IV (London: Eyre & Spottiswoode, 1969), 161-2. The White or 'Lesser' Hall (no longer extant) was approximately a quarter of the size of Westminster Hall, and around three-quarters of the combined floor area of the old House of Lords and House of Commons. Given the huge size of the assembly, doubt may therefore be cast on Favent's placing of the initial meeting of the Merciless Parliament in the White Hall.

and the size of the assembly, with all the lords both spiritual and temporal, the retinues of the Appellants, and indeed a London public eager to witness the spectacle, demanded a chamber of substantial size. The Westminster Chronicle refers repeatedly to the 'full parliament' and states that 305 knights and esquires on the Appellants' side alone flung down their gauntlets to challenge anyone who countered their allegations, and further evidence indicates that Rufus's hall would have been the logical location.[84] In 1397, for the Parliament in which Richard finally gained revenge on the Lords Appellant, Westminster Hall was unavailable due to its reconstruction. The lesser chambers of Westminster Palace were evidently not capacious enough to accommodate such a gathering because Richard had a large temporary hall specially constructed 'in the middle of the palace yard.'[85] It seems reasonable to assume, therefore, that at least the opening and concluding sessions of this assault on Richard's kingship took place in Westminster Hall.

Understandably, 'the king had wanted to have nothing at all to do with it on this occasion', but on the opening day of the 1388 Parliament he was seated on the dais as the five appellants entered the hall in 'costly robes leading one another by hand with an innumerable company following them.'[86] Crowds were so great that some had climbed on to the roof and were peering in through the lantern. As proceedings opened, Richard was forced to listen as the interminable litany of charges were read out and prosecuted against his intimates.

By the end of what became known as the 'Merciless Parliament', five of his closest advisors were found guilty of treason; the two who had not already fled were executed in customary ghastly fashion.[87] Four of Richard's chamber knights were also executed, including Sir Simon Burley, his boyhood tutor – the man who on coronation day had swept the exhausted boy up into his arms and carried him aloft into Westminster Hall.

---

[84] *WC*, 282.
[85] Adam of Usk, 22.
[86] Walsingham, 350; Saunders, 76.
[87] De Vere was exiled; De la Pole died in exile in Paris; Brembre was executed; Tresilian was executed; Neville was exiled.

The pleadings of the king and the kneeling supplications of Queen Anne only succeeded in commuting Burley's sentence from a public disembowelling to simple beheading.[88] Those allies not executed lost their lands and possessions. Richard's inner court was purged; two dozen lords and ladies were expelled, and it ceased to function as a social unit.[89] Then, after four months of impotent presidency, Richard had to provide the customary banquet in Westminster Hall to thank the Merciless Parliament for its work, work that had accomplished his wretched humiliation and political emasculation.[90]

In their turn, the Appellants declined in popularity. Internal strife diluted their power, and on 3 May 1389, Richard, now of age, strode into the Privy Council and, according to Walsingham, demanded to know how old he was.[91] After twelve years of hollow kingship, he then laid hold of the Great Seal, 'clasped it to his bosom', and declared his reclamation of the royal executive.[92]

[88] Saul, 194.
[89] Walsingham, 848, 850; Caroline M. Barron, 'Richard II: Image and Reality', in Dillian Gordon, *The Wilton Diptych* (London: National Gallery, 1993), 17.
[90] *WC*, 342; Saul, 195.
[91] Saul. 199, 200.
[92] Walsingham, 864, 866; *WC*, 390, 392; Saunders, 76.

Chapter 5

MEDIEVAL WESTMINSTER HALL

Part 2: DUDGEON, DEMI-GODS AND DEALING: RICHARD II'S REBUILDING OF WESTMINSTER HALL

Not all the Water in the rough rude sea
Can wash the Balm off from an anointed King

Shakespeare, *Richard II*, 3. 2.

DUDGEON

It may be argued that when Richard II refurbished Rufus's great hall in the early 1390s he did so because its Norman aspect was embarrassingly passé. After all, lesser magnates held court in un-aisled halls with splendid open roofs, constructed in the contemporary pointed 'Gothic' style.[93] Given its status, the refitting of Westminster Hall seems long overdue. But it must be allowed that there may have been psychological reasons for Richard's remodelling of the hall. Compared to other English monarchs – his grandfather Edward III for example – Richard was not much of a builder, but shortly after the mortifications described above, the condition of Westminster Hall did draw his attention.[94] Here words like 'repair' 'refurbish' and 'remodel' become inadequate.[95] Richard gutted Westminster Hall. All vestiges of William Rufus's aesthetic were erased. All that remained were the lower portions of the longitudinal walls below the string course.[96]

---

[93] For example, Penshurst Place, Kent, *c*. 1341, constructed for the London merchant and financier Sir John Pultenay; and probably the great hall of Kenilworth Castle, Warwickshire, constructed for John of Gaunt in the 1380s.
[94] Cooper (1936), 179.
[95] The contemporary accounts call the work at Westminster a 'repair', *HKW*, 528-29.
[96] Much of the masonry of the gable walls was retained, probably for reasons of economy, Wilson, 44.

I propose that Richard's bitter personal experience of the hall compelled his actions.[97] For his ancestors Westminster Hall was an architectural expression of kingship, a theatre where the might of that kingship was played out with spectacular pageantry. For Richard it had become the symbol of his impotence. It had witnessed the nadir of his kingship; indeed, short of deposition, in the crises of 1386-88 it is difficult to see how Richard could have been more abased.[98] In that place he had endorsed edicts that condemned loyal friends to torture and death. During that Merciless Parliament he had looked on as his own wife, Queen Anne, knelt and begged to her inferiors for the life of dear Sir Simon Burley, only to be denied.[99] Is unsurprising that for the rest of his reign, despite the hall being the seat of administration, Richard was to spend little time in Westminster.[100]

The events of the 1380s undoubtedly left long-term psychological scars upon Richard. In 1393 he attempted some redress for friends who had died in consequence of his impotence by a posthumous adjustment of status. With a display of pomp he had the bones of his favourite De Vere brought back from exile and reburied in the family tomb. At Richard's behest, the monks of the Abbey of St Mary Graces, near the Tower, agreed to celebrate the anniversary of the death of Sir Simon Burley, and, by their inscribing his name in their martyrology, he attained the status of martyr.[101] A letter written to Albert of Bavaria, Count of Hainault, in 1397 shows that the wounds, even then, were still raw. Richard begins by thanking God for protecting him, 'since the very cradle', from enemies:

---

[97] Suggested by Wilson, 42.

[98] Barron (1993), 17. Interesting is the way Richard pursued the canonisation of his grandfather Edward II in the late 1380s and 1390s, Barron (1993), 18. Richard personally commissioned a book of miracles associated with the tomb of Edward II. After his own experiences Richard may have viewed the elevating of a deposed king to the status of saint as some form of insurance against further attacks on his own kingship; also Lindley, 73; McKisack, 467; Eberle, 246.

[99] *The Kirkstall Chronicle 1355-1400*, ed. M. V. Clarke & N. Denholm-Young (Manchester: The University Press, 1931), 116.

[100] Nigel Saul, 'Richard II, York, and the Evidence from the King's Itinerary', in Gillespie (ed.), 1997, 86.

[101] Harold F. Hutchinson, *The Hollow Crown, a life of Richard II* (London: Eyre and Spottiswoode, 1961), 168.

> … especially those of household and intimacy, whose contrivances are more destructive than any plague. For nobleman and leaders of our own household, whom we have respected, whom we have brought to the highest peak of honour, to whom we have opened a generous hand and whom we have treated with real affection, have for long, and since we were of tender years, traitorously conspired to disinherit our crown and usurp our royal power, raising themselves with many abettors of their iniquity to rebel against our royal will, publicly condemning our faithful servants to death, and doing whatsoever they pleased … They have striven damnably to spend their malice even upon our own person, having wrongfully usurped the royal power by going about among our privy affairs so that they left us hardly anything beyond the royal name …'[102]

Interesting is Richard's choice of tense in that passage: the present perfect. In 1397, nearly ten years after the events, it is as if Richard was still in the midst of the nadir of the 'Merciless Parliament', still mired in his own impotence. Richard, however, had already served the cold dish of revenge before composing the correspondence. The letter is his explanation of why the Lords Appellant had been punished - death for most, banishment for others - 'so that posterity may learn what it is to offend the royal majesty, established at howsoever tender years …', that 'those who contrive wickedness against King Christ the Lord may be hammered back into confusion and prevented from doing the like.'[103] Could such severe and enduring psychological trauma have led to the destruction and rebuilding of an edifice? Interestingly, the argument that the rebuilding of Westminster Hall was a dramatic act of pique, a vindictive response to the events of the 1380s, can be made with some contextual foundation.

[102] 'Letter from Richard II to Albert of Bavaria, Count of Hainault', in John H Harvey (trans.), 'The Wilton Diptych – A Re-examination', *Archaeologia* 98 (1961), pp. 23-24. Compare the letter of Thomas Bekynton to Emperor Manuel Palaeologus, in Myers (ed.), 174- 175.

[103] See Christopher Fletcher, *Richard II: Manhood, Youth, and Politics, 1377-99* (Oxford: Oxford University Press, 2008), 43, for a discussion of 'the manly pursuit of vengeance' expected of a king.

In 1394 Queen Anne died. By all accounts, the couple seem to have enjoyed a close relationship.[104] According to Walsingham, Anne was hardly allowed to stray from Richard's side.[105] During their years together, they spent long periods at the Royal Palace at Sheen on the Thames, and on 'La Nayght', an island in the river, Richard ordered a pavilion constructed so that the couple could enjoy privacy. As with their grandfather Edward III, Sheen appears to have been one of the couple's favourite palaces.

Of the Royal Palace of Sheen no trace now exists. There, beloved Queen Anne died, and in an act of destructive grief Richard ordered the palace to be obliterated.[106] It is not unreasonable to contend, then, that the humiliations of the 1380s, many associated with Rufus's great hall, fuelled a similar theatrical act of obliteration on a work of architecture.

DEMI-GOD

Further, and not unconnected, motives for the transforming of Westminster Hall may also be posited. Increasingly, after the rebirth of his kingship in 1389 Richard developed into a king with, in Nigel Saul's phrase, 'a myopic preoccupation with the symbols of regality.'[107] Newly invigorated, that regality in the 1390s gradually took on a more autocratic tone. It was a kingship characterised by an emphasis on the prerogative, and the irresistible force of the royal will, a royal will that demanded strict obedience if the realm was to prosper. The king himself was above the law, indeed, he was the lawgiver, to whose edicts all were

[104] Saul (1997), 455. Richard adopted the plant Rosemary as his own the emblem of Anne of Bohemia; Gordon (1993), 21. According to Anthony Steel, after Anne's death in 1394 Richard became increasingly psychologically unhinged, *Richard II* (Cambridge: Cambridge University Press, 1941), 41, 42, 203, 204.
[105] Walsingham, 737.
[106] Adam of Usk, 18; According to Walsingham, Anne's funeral was 'famous because of its cost', surpassing 'all others of our time', 960. The ceremony in Westminster abbey contained an incident indicative both of Richard's feelings for Anne and his capacity for sudden and uncontrolled rage. The Earl of Arundel arrived late. Richard reacted by seizing a cane and striking him with such force 'that he collapsed and his blood flowed profusely over the pavement… the king would have liked to kill him in the church had he been permitted', Walsingham, 960. For a further instance of a hysterical outburst by Richard, see Myers (ed.), 147.
[107] Saul, 'The Kingship of Richard II', in Goodman & Gillespie (eds.), 1999, 55.

subject.[108] A notandum, then, is that that Richard, the divine lawgiver, transformed Westminster Hall, the forum of law in England.

Such assertiveness was rooted in Richard's revitalised perception of himself. The more customary language of kingly address was replaced by more elevated expressions such as 'your majesty', 'your royal majesty', or 'high majesty', rather than merely 'highness', expressions which confirmed the theocratic component to his kingship. It became Richard's custom to sit enthroned in splendour from dinner until vespers observed by courtiers, who, whenever the gaze of the king fell on them, were expected to bend the knee.[109] An original design for the tomb he commissioned for himself and Queen Anne in 1395 incorporated a celestial court of saints and angels – the first by any British monarch to do so.[110] Perhaps this was a king anticipating canonisation, perhaps enshrinement, as Richard himself had pursued just a few years earlier for his great-grandfather Edward II.[111] Further, it is probable that Richard was the last English king to employ ancient liturgical tradition which, upon his arrival in church, welcomed the monarch with chants celebrating his Christ-like nature.[112] This, then, is a king cultivating a mien of remoteness, reinforcing the perception of a being who occupied a different, higher, plane than his subjects. It is interesting in this regard that in his letter to Albert of Bavaria, the actions of the Lords Appellant against Richard were for him heretical, designed to 'contrive wickedness against King Christ the Lord.'[113] It was a mind-set connoted two years earlier by the juxtaposed hexameters of the epitaph Richard commissioned for his tomb in Westminster Abbey: 'He threw down all who violated the royal prerogative; he destroyed heretics and scattered their friends.' By associating the royal prerogative with the destruction of heresy, for Richard, heresy was synonymous

[108] Saul, 'Kingship', *passim*; Tuck, *DNB*.
[109] Saul, 'Kingship', 40, 46, 49. One of the reasons given for Richard's revenge on the Appellants in 1397 was because they had 'prejudiced [Richard's] majesty and regality', Adam of Usk, 23.
[110] Phillip Lindley, 'Absolutism and Regal Image in Ricardian Sculpture', in Gordon, Monnas & Elam (eds.), 1997, 64.
[111] Saul, *Richard II*, 323.
[112] Wilson, 275, nt. 10.
[113] Saul, *Richard II*: 'To Richard rebellion against a king was equivalent to rebellion against God', 325.

with challenging his divinely ordained kingship. Richard, in these examples, is surely not placing himself on the same plane as Christ, but the above conveys an image of a king, always mindful of the divine origin of his rule, perceiving himself a demi-god.[114]

The seeds of such a self-perception had been sown at the beginning of his kingship. Notwithstanding the intrinsic divinity of the coronation ceremony itself in the sacred setting of Westminster Abbey, replete with references to the divine origin of his rule and culminating in Richard's anointment as God's King with holy oil, the celebratory parade of the previous day would have done little to imbue Richard with any temporal sensibilities.[115] On a day of 'clamour and clangour' they had processed with spectacular pageantry through London, Sir Simon Burley in the vanguard carrying the King's great sword on high.[116] On reaching the Great Conduit in Cheapside, Richard was confronted by a celestial scene: the conduits had been transformed into a vision of heavenly Jerusalem. Four virgins dressed as angels, scattering gold leaves and coins. The angels offered Richard a cup of wine which miraculously flowed from the conduit. From the midst of the heavenly city an ingenious mechanical angel bowed and gave the boy a crown of gold.[117]

Such very public endorsement of Richard's divinity was repeated fifteen years later in 1392, during the triumphal procession – almost a second coronation - organised by prominent Londoners to assuage Richard's wrath at their 'offence against the King's majesty', and to proclaim their renewed subjection to his will (discussed below).[118] Just as

[114] Saul, *Richard II*, 449, 450, 453. Such a deific self-perception informed Shakespeare's characterisation two-hundred years later. Richard sees himself as a type of sun-god, *King Richard II*, Act III, scene 2, and his 'appearance' before Bollingbroke and the rebel army on the walls of Flint Castle, III, 3, where he appears as 'the blushing, discontented sun / from out of the fiery portal of the east', later stating that '… no hand of blood and bone / can gripe the sacred handle of our sceptre.' Henry III was also a king concerned with the sacredness of his kingship, as the rebuilding of Westminster Abbey attests; see Nicola Coldstream, *The Decorated Style: Architecture and Ornament, 1240-1360* (London: British Museum, 1994), 23-27, 78, 121.

[115] See Walsingham, 144, 148, for references to the God-given nature of Richard's Kingship during the coronation ritual.

[116] Walsingham, 138, 140.

[117] Caroline M. Barron, 'Richard II and London', in Goodman & Gillespie (eds.), 1999, 150.

[118] Walsingham, 926. The procession, 'a civic triumph', is discussed in Gordon Kipling, *Enter the King: Theatre, Liturgy, and Ritual in the Medieval Civic Triumph* (Oxford: Clarendon Press, 1998), 12-21.

Christ acceded to Heavenly Jerusalem, the procession symbolised the Christ-King Richard regaining possession of his city, and, fittingly, divine imagery abounded.[119] The procession began by an act of abject submission. A garlanded Richard, clad in vestments of purest white and a robe of red and gold, was met by the warden of London at the city gates. Holding a sword to his own throat, he offered Richard the keys to a city, proclaiming that London, 'prostrated at your feet ... surrenders and comes ready to be to be subject to your will [and] ... begs, amid her tears, that the merciful King will deign to enter his chamber.'[120] Such sacrificial submission is little removed from outright worship.[121] As Richard and Queen Anne progressed through the streets on pure white horses clad 'in trappings of white cloth-of-gold and red together', in a series of pageants, angels sang and scattered shimmering fragments of gold; angels descended from on high, lowered from specially erected platforms; angels sang 'heavenly songs' from the roof tops; they formed rings of adoration around an image of the Almighty.[122] Arriving at the final tableau featuring John the Baptist, the first saint heralded Richard unequivocally with, 'Behold, the Lamb of God.'[123]

Always of heightened aesthetic sensibility, Richard knew that his preternatural power could be communicated to his subjects iconographically. Thus, his extensive use of badges and livery, the sunburst on his standards, garments and other personal accoutrements, the splendour of his dress - also replete with heraldic and divine symbolism.[124] The stone statues he commissioned for the interior of Westminster Hall in 1385 numbered thirteen, a number that to the anagogical medieval mind would instantly

---

[119] Barron (1999), 152, 153. Kipling: 'the pageantry does not merely compare Richard to Christ. Rather it stages Richard's epiphany as a type of Christ', 17, also 42, 43.

[120] From the contemporary poem *Concordia facta inter regem Riccardum II et civitatem Londonie* (1393) by Richard Maidstone, a portion of which is translated in Rickert (1948), 35-39; see also McHardy, 273-275.

[121] Fletcher sees this triumphal entry as London finally displaying its acceptance of Richard's authority. It 'served to restage and renew his legitimacy as king, and showed that Londoners wanted Richard to behave 'as a forgiving Christ-king', 214.

[122] *The Brut* in A. K. McHardy, *The Reign of Richard II* (Manchester: Manchester University Press, 2012), 271; Gordon (1993), 58.

[123] Fletcher, 214.

[124] For the sun emblem see Lisa Monnas, 'Fit for a King: Figured silks in the Wilton Diptych', in Gordon, Monnas & Elam (eds.), 1997, 167-169.

suggest Christ and the apostles.[125] And then there is the exquisite Wilton Diptych, in which Richard not only keeps company with principal saints, a convocation of angels, and the Virgin and Christ-child, but ensures that he is the cynosure of this celestial assembly.[126]

The Wilton Diptych was completed according to the dictates of the patron - to a given pattern - rather than being a portrait executed from a sitting.[127] Although Richard is depicted as the boy-king, current consensus is that it was painted *c.* 1395. Thus, via the personally commissioned Wilton Diptych we have an insight into Richard's mind in the mid-1390s; and it is a mind obsessed with the divinity of his kingship. The angels, God's agents and man's guardians, wear the livery of Richard: badges of the white hart and gilded broomcod necklaces. In the earthly realm, such badges were only worn by the king's supporters and granted personally by him.[128] The broomcod contains the seeds of the Broom plant, the *planta genista*. The future growth of the Plantagenet line is thus entrusted to the agents of God's will. Then, there is the somewhat ambiguous position of Richard's hands (Fig. 5.16). They are not in an attitude of prayer.[129] Are they about to receive something? Or, perhaps, have they just completed an act of giving? An angel holds the standard of St George with, contained the orb, a miniature of Richard's kingdom (Fig. 5.17).[130] It is plausible, then, that Richard has vouchsafed the kingdom of England, represented by the banner and the orb, into the care of the Virgin.[131] Richard, therefore, rules by proxy for Christ and the Virgin. Conversely, if Richard is in the act of receiving, it is equally plausible, given Richard's youthful appearance, that the painting declares the

[125] Wilson, 54.
[126] Saul, 'Kingship', 55.
[127] Gordon (1993), 24; Harvey (1961), 1, 17.
[128] Gordon (1993), 49, 50; *AC*, 394, 395
[129] Harvey (1961), 19.
[130] This discovery was made in 1993 during restoration and cleaning. The orb measures only 1 cm in diameter but within it, set in a sea originally of silver leaf, is a depiction of a tiny island surmounted by trees and a white castle. On the sea is a ship in full sail. It is as though Shakespeare was familiar with this detail: … 'this sceptred isle / … / This precious stone set in a silver sea', Gaunt's speech in *Richard II*, 2. 1; Gordon (1993), 57; see also his 'The Wilton Diptych: An Introduction', in Gordon, Monnas & Elam (eds.), 1997, 22-26.
[131] See Gordon (1997), 23-26, for the interpretation that Richard is presenting the Kingdom of England, represented by the image in the orb, as a dowry to the Virgin; also Saul, *Richard II,* 306, 307.

divine source of the kingdom entrusted to him on the day of his coronation. With either interpretation divine provenance is paramount.

In addition to being a national emblem, the banner of the red cross in the diptych was also closely associated with the resurrection. Perhaps, in cloistered moments of devotion, Richard saw the banner as a symbol of the resurrection of his kingship in the 1390s. And here it is important to remember that, in the milieu of various interpretations of the work, from symbol of a diplomatic alliance to symbol of an enigmatic fraternity, the Wilton Diptych is a small, portable object designed for private devotion.[132] Richard took it on his campaigns to Ireland.[133] And as Richard gazed, rapt, at the vision of heavenly supporters and symbols of divine right, the object would take on a much more profound meaning than that of a commonplace object of personal devotion: it would be an object of personal reassurance. The diptych was a reaffirmation that, despite all the assaults on his regality, Richard was divinely ordained as king from boyhood, and could count on angelic and saintly champions.[134] The Wilton Diptych, then, is the essence of Richard's rationale in the 1390s: the consolidation of his battered kingship by means of an obsessive focus on, and dissemination of, symbols of its divine provenance.[135]

In light of the foregoing, it is reasonable that Richard, following the resurrection of his once moribund kingship, would also put his own deific stamp on the space where his divinity interacted with the workaday public, Westminster Hall. Richard, the demi-god, swept away William Rufus's hall, and commissioned a magnificent new building replete with celestial imagery. He commissioned the transformation of the north entrance into an interpretation of a great church façade (Fig. 5.18). Two new towers not only framed an ecclesiastical doorway, but provided space for an array of statuary redolent of the screen

[132] Saul, *Richard II*, 304.
[133] *AC*, 135.
[134] A perception of Richard that prevailed until Shakespeare's day: 'God for His Richard hath in heavenly pay / A glorious angel. Then if angels fight, / Weak men must fall, for heaven still guards the right', *Richard II*, 3. 2; and, 'Yet know: my Master, God omnipotent, / is mustering in His clouds on our behalf / Armies of pestilence, and they shall strike', 3. 3.
[135] See Davies, 'Richard II and the Church', in Goodman & Gillespie (eds.), 1999, 104, for a more prosaic interpretation of the diptych.

facades of great cathedrals (Fig. 5.19 - 5.21).[136] Entering the hall, therefore, one would pass within touching distance of former kings and queens of England - dynastic imagery declaring Richard's prerogative – and, once inside, the eye would be drawn aloft to gaze upon more heavenly beings. As has been noted in this chapter, angels were a recurring theme in episodes affirming Richard's kingship. The king also commissioned images of angels for his tomb and for the Wilton Diptych. In the later Middle Ages, angels were understood to be guardians and champions of faithful, sometimes afflicted, souls.[137] It is no accident, therefore, that this afflicted king commissioned an array of angels, many bearing his arms, to miraculously sustain the impossible roof (Figs. 5.22-5.23). Once the celestial host was assimilated, the gaze could then be drawn forward, focused by thirteen hammer-beam trefoils and the audacious cathedral-inspired arched ribs, to a divine king, enthroned before a reredos of regal statuary (Fig. 5.16).[138]

DEALING

Thinking about Westminster Hall as the interface between divinity and commonality leads us to a final ingredient in the matrix of reasons for its transformation. As mentioned earlier, in the early 1390s Richard was in chronic dispute with his neighbours along the Strand, the Londoners. The city had conspicuously failed to rally to Richard's support during the Appellant crisis.[139] Further, Richard viewed the city and its wealthy merchants

---

[136] Wilson, 49-51. Wilson sees similarities in Richard's entrance to both Westminster Abbey and old St Pauls; Phillip Lindley with the west end of Exeter Cathedral, 77-78.

[137] See Jacobus de Voragine, *The Golden Legend* … trans. William Granger Ryan, Vol. II (Princeton; Chichester: Princeton University Press, 1993), 207-209, which states 'There are many reasons for honouring and praising the angels. They are our guardians, our servants, our brothers and our fellow citizens; they carry our souls into heaven; they present our prayers before God; they are the noble soldiers of the eternal King, and consolers of the afflicted … We owe them honour because they are our guardians.' (207); also the fourteenth-century tract, *The Book of the Craft of Dying* (anon.), in Robert Swanson, *Catholic England: Faith, Religion and Observance Before the Reformation* (Manchester: Manchester University Press, 1993), 138, 146; also Ps. 34: 7: 'The angel of the Lord encamps around those who fear him, and delivers them'; Dan. 10: 5, 13, 20-21; Dan. 12: 1; Matt. 18:10; Matt 26: 53; Tobit chapters 5-12.

[138] Wilson also sees the thirteen figure dynastic statuary as planned for the south wall behind the king's throne as 'altarpiece-like', 54. Only six were eventually set up. See also p. 59 for the 'celestial resonances' of the roof.

[139] Knighton, 406.

as a source of income, and in the early 1390s it was, in his view, being parsimonious.[140] When in 1392 Richard asked the Londoners for a substantial loan, despite being more than able to supply the cash, they refused, according to Walsingham, 'in an insolent and extraordinary disrespectful manner.'[141] Richard, under the guise of dealing with complaints ranging from bad governance, rambunctious and violent behaviour on the streets, to the amount of offal being swilled through those streets, retaliated. He ousted the city's officers and installed his own, withdrew the city's liberties and imposed a colossal fine of £100,000.[142] The punishments hit Londoners hard - Walsingham describes their plight as 'hovering between the hammer and the anvil' - so the citizens decided to patch up the dispute by what might now be called 'corporate schmoozing.'[143] As noted, the city threw a lavish and somewhat sycophantic party for Richard and Queen Anne, complete with expensive and exotic gifts. The cavalcade rolled through bunting bedecked streets, past a variety of spectacular and opulent tableaux proclaiming none too subtly the divinity of the monarch, and past the conduits inevitably flowing with wine, to finally arrive at Westminster. Once enthroned there, the citizens presented Richard with two silver-gilt basins full of gold coins, and begged their king that through his mercy and 'special grace' their liberties and franchises be restored.[144] A lavish banquet followed. Knighton reports that 'so many and such marvels and honours were lavished upon the king, that no other king of this realm in past times can be remembered to have enjoyed the like.'[145] The panegyric mollified Richard. The festivities went on for two days, and subsequently many of the penalties were rescinded.

---

[140] See Barron (1999), pp.131, 135 - 136, for Richard's financial relationship with the city.

[141] Walsingham, 924; Walsingham, writing from a safe distance in St Albans, had a low opinion of Londoners. His engaging prose describes them as the 'haughtiest, most arrogant and most avaricious of all the people of the world… disparagers of the religious… impoverishers of the common people', 924; See also *WC*, 497; Caroline M. Barron, 'The Quarrel of Richard II with London', in Du Boulay & Barron (eds.), 1971, 178, 179; also Barron (1999), 139.

[142] Barron (1971), 189.

[143] Walsingham, 926.

[144] *The Brut*, in McHardy, 271.

[145] Knighton, 548; Walsingham, 930; *WC,* 504, 506; Barron (1999), 152, 153.

It is noteworthy, then, with regard to considering possible motives for the reconstruction of Westminster Hall, that a year before work began Richard was networking potential financial backers in an antiquated, stylistically redundant architectural environment. In the modern world of the financial magnates, image is everything. Multi-nationals construct extraordinary and singular corporate edifices to communicate identity and mission. Shortly after the banquet with London financiers and power-brokers, Richard was to begin construction of his own modern, magnificent and, just as importantly, *London* symbol that his kingship expected to do business.

For Richard, a secure grip on his kingship seemed forever to elude his grasp. Even after the dramatic assertion of his majority in 1389 his acquisition of power was gradual, characterised by some as a serendipitous 'drift.'[146] After the degradations of the 1380s it is understandable that when he had attained a degree of power, Richard set about his only major contribution to the history of architecture. How could he bear to preside in the chamber that had seen his utter abasement? Richard, a king with a taste for theatrical displays of will, expunged the evidence. But if the great hall of William Rufus had astounded contemporaries by its scale, Richard was to commission a structure which would astound by its aesthetic, an aesthetic which was a crucial component in an iconographic campaign designed to shore up his chronically unstable kingship. Richard stopped short of putting an altar and a crucifix in the hall, but his Westminster Hall is the architectural monument to a king obsessed with his sacred status as anointed godhead. And, surely, in such a celestial court watched over by angels, no one would dare to depose a god.

---

[146] Fletcher, Chpt. 11, *passim*.

Chapter 6

THE HAMMER-BEAM ROOF OF WESTMINSTER HALL AND THE STRUCTURAL RATIONALE OF HUGH HERLAND.

For every wright who has a house to build rushes not to begin with hasty hand, but will bide a while and send out his heart's line …, his purpose for to win.

Geoffrey Chaucer[1]

In this chapter I turn my attention to the pivotal construction in the history of hammer-beam development: the roof of Westminster Hall. Begun by Hugh Herland in late 1393, its structure, especially in details of form and ornament, was to have far-reaching effects on fifteenth-century display carpentry.

Herland's roof is *the* most analysed example of medieval English carpentry. Art historians, architects and engineers have argued at length about how the roof performs structurally, with no agreement reached.[2] I summarise these debates and introduce a hitherto relatively neglected perspective: that of the carpenter Hugh Herland, a craftsman who had no scientific knowledge of structural mechanics, and to whom

[1] *Troilus and Criseyde*, Bk. I, 1065 (a synthesis of Windeatt's translation (Oxford: Oxford Paperbacks, 2008), and the original text (Oxford: Oxford University Press 1992).

[2] Late twentieth-century debate (and rancour) is found in: Lynn T. Courtenay & Robert Mark, 'The Westminster Hall Roof: A Historiographic and Structural Study', *Journal of the Society of Architectural Historians,* Vol. 46, No. 4 (Dec., 1987), pp. 374-393. Jacques Heyman; Rowland Mainstone; Lynn T. Courtenay; Robert Mark, 'Letters', *Journal of the Society of Architectural Historians*, Vol. 47, No. 3 (Sep., 1988), pp. 321-323. Yun Sheng Huang *et al.*, 'Westminster Hall's Hammer-Beam Roof: A Technological Reconstruction', *APT Bulletin,* Vol. 20, No. 1 (1988), pp. 8-16. Lynn T. Courtenay, 'The Westminster Hall Roof: A New Archaeological Source,' *Journal of the British Archaeological Association* 143 (1990), pp. 95-111. E. Toby Morris; R. Gary Black; Stephen O. Tobriner, 'Report on the Application of Finite Element Analysis to Historic Structures: Westminster Hall, London', *Journal of the Society of Architectural Historians,* Vol. 54, No. 3 (Sep., 1995), pp. 336-347. Rowland Mainstone, 'Structural Analysis, Structural Insights, and Historical Interpretation', *Journal of the Society of Architectural Historians*, Vol. 56, No. 3 (Sep., 1997), pp. 316-340. Gene Waddell, 'The Design of the Westminster Hall Roof', *Architectural History*, Vol. 42 (1999), pp. 47-67.

modern dogma of 'form following function' would have been both alien and baffling.[3] I examine, not how the roof may be performing now, as judged by modern-day historians, archaeologists and engineers, but how Herland *thought* it would perform in 1393. This task is accomplished by the use of two original sources: the examination of unpublished drawings of the roof prepared by HM Office of Works in 1914 at the time of the roof's repair, and my own 1:4 reconstruction of one of the lower hammer-beam brackets (Fig. 6.1). The process leads to some surprising conclusions regarding the differing priorities Herland assigned to structure and form.

BEFORE WESTMINSTER: HERLAND THE CRAFTSMAN

Before we go into the specifics of his carpentry at Westminster, it is important to assess Herland's experience before he began the project. His empirical knowledge would inevitably have imbued his design decisions.

Hugh Herland was steeped in the mysteries of carpentry. From the sparse documentary evidence it is reasonable to conclude that his father was a carpenter, and probably his grandfather before him.[4] Early in his career, Hugh's putative father William Herland (d. 1375) worked under the King's Carpenter William Hurley (d. 1354). Hurley carpentered the fabulous roof of St Stephen's Chapel, Westminster (*c.* 1348), for Edward III, and was probably the 'subtle craftsman' who 'wrought and cunningly framed' the carpentered *tour de force* of the vaulting and lantern over the crossing at Ely Cathedral (completed c. 1338; see Fig. 1.38).[5] William Herland succeeded Hurley as the England's pre-eminent carpenter, going on to design, construct, and supervise a wide variety of royal works, from ecclesiastical stall-work to bridges and major roof structures.

---

[3] My approach is an adaption and extension of that of William Harvey, 'Westminster Hall and the Woodman', *The Builder*, Vol. 121 (1921), 19 Aug, pp. 220-221; and, although significant points of disagreement exist, that of Waddell.

[4] The following biographical details are based on the relevant entries in *EMA*, and Lynn T. Courtenay, 'Herland, Hugh', *Oxford Dictionary of National Biography*, Oxford University Press, 2004; online ed., Jan 2007 <www.oxforddnb.com>, accessed 12 May 2014.

[5] Monk of Ely, *Anglia Sacra*, I, 643, translated in Salzman, 390.

Thus, from a small boy Hugh was surrounded by carpentry, carpenters, and their tools and designs. And he was instructed, not in some village carpenter's yard knocking together hovels and handcarts, but in an elite atelier designing and framing state-of-the-art works for the Crown.

Throughout his career Hugh exploited this privileged grounding. He became a craftsman of versatility and virtuosity, making and designing a range of items from choir stalls and tomb canopies of the most delicate filigreed tracery, to siege engines and monumental roofs (Figs. 1.22-1.24, 6.3 & 6.4). Structural fundamentals such as how the rafter foot improved the stability of a rafter couple, or the utility and fashioning of a bracket, would be elemental and ingrained. As with any highly trained and experienced craftsman, the application of such basic knowledge would be automatic and subconscious, the most demanding of techniques accomplished with a nonchalant dexterity baffling to those without the craft.

It is not certain if Herland constructed a hammer-beam roof before Westminster. Scholars have suggested, indeed declared, that Herland built a shallow-pitched hammer-beam over the chapel at William Wynford's New College, Oxford (comp. 1386).[6] While Herland certainly worked on the carpentry at New College during the period, the evidence that he built a hammer-beam roof there is speculative and convoluted.[7] Similarly, scholars have conjectured that Herland advised on the construction of the roof of Dartington Hall, Devon (*c.* 1388-99), for Richard II's half-brother, John Holland.[8] As we will see, Herland spent a considerable amount of time on the edge of the West Country in the early 1390s at Winchester, but the imprecise decadal date for Dartington is problematic if it is to be added to Herland's purview before he began work at Westminster in 1393. Further, any involvement must have been remote, as the nearly

---

[6] John Harvey, *The Perpendicular Style 1330-1485* (London: Batsford, 1978), 118.

[7] Lynn T. Courtenay, 'Westminster Hall and its Fourteenth-century Sources', *Journal of the Society of Architectural Historians*, Vol. 43, no. 4 (Dec. 1984), 307-8.

[8] *EMA*, 139; Courtenay (1984), 304. The original roof is lost; the present hammer-beam roof is a reconstruction of *c.* 1931 by William Weir, not intended to be a replica of the original. For a discussion of the original roof see Anthony Emery, *Dartington Hall* (Oxford: Clarendon Press, 1970), 161-64.

300 mile round trip from Winchester to Dartington would have been arduous for Herland, then probably in his sixties.

HERLAND IN WINCHESTER

Herland's unparalleled empirical knowledge was rooted, then, in fourteenth-century high-status carpentry practice. Irrespective of whether or not he had personally carpentered a hammer-beam roof, he would certainly have had detailed knowledge of their mode of construction. Why can this be so confidently avowed?

In 1390 Herland was appointed to oversee works at Winchester for a period of seven years. He spent extensive periods in the town, working both on Winchester Castle and on Bishop William Wykeham's new college buildings. He was a frequent dinner guest of Wykeham.[9] Indeed, Herland's sojourn at Winchester was so lengthy that that he arranged to have his pension paid to him there rather than at his home in Kingston.[10] When work began on Westminster Hall in late 1393, he probably, at least initially, divided his time between the locations, and it is notable that the roof was framed at Farnham, a location closer to Winchester than to Westminster.[11] Thus, it is important to note that Herland was practicing carpentry chiefly in Winchester during the very period in which Richard II's plans for a revamped Westminster Hall were being mooted.

Domiciled in Winchester, it is beyond reasonable doubt that Hugh would be familiar with the roof over an ancillary building in the close of the cathedral: the Pilgrims' Hall (Fig. 2.13). The only conceivable reason that Herland would not have

[9] *EMA*, 138.
[10] *EMA*, 139.
[11] *HKW*, 529-30; *Calendar of the Close Rolls, Richard II,* Vol. 5, 1392-1396 (London: HMSO, 1925), 352. Approximate distances: Farnham to Winchester: 27 miles; Farnham to Westminster: 45 miles. Of course, Herland's choice of Farnham as the site to frame the Westminster roof may have been due to its propinquity to the woodland sources of the timbers. Timbers were obtained from woods at: Odiham, Hampshire (8 miles NE of Farnham); Aliceholt, Hampshire (5 miles SW of Farnham); Stoke D'Abernon, Surrey, (22 miles NW, a location closer to Westminster, at 20 miles distance); timbers for rafters were obtained from Northaw, Hertfordshire (60 miles to the NE of Farnham, 18 miles N of Westminster), *HKW*, 529. Conversely, timbers may have been sourced from Hampshire forests simply because Herland was already engaged in Winchester.

examined this remarkable, innovative, and apparently rare piece of carpentry is that hammer-beam roofs were by then so commonplace that he had no need. But, as we have seen in Chapter 4, the reverse seems to have been the case.

Inspecting the north-eastern range of Pilgrims' Hall with an expert eye, Herland would have discerned what should have been an aisled hall, but with truncated arcade posts, their remnants supported on immense brackets. Currently he faced similar challenges: his king's demands to convert an aisled hall into a clear span building, although unlike Pilgrims' Hall, William Rufus's hall was a space of vast proportions. As he gazed at the striking, if somewhat heavy, construction at Winchester, he may have admired the way the lower brackets bore a significant portion of the roof's weight and transmitted it, by means of the diagonal arch braces, to a lower point on a buttressed wall. For Westminster, however, those massive arch braces would need lightening to meet the more refined tastes of the royal patron. Being steeped in the mysteries of carpentry, Herland may have noted that the hammer beam and hammer post arrangement was reminiscent of an enormous common-rafter foot. It would be elementary for him to understand that the rafter foot created a compressive triangle in the lower portion of a roof, triangulation which improved the roof's performance in dealing with lateral thrust. Lateral thrust was *the* problem he would have to solve at Westminster, but of a magnitude never before tested. Regarding visual appeal, he may have noted with approval the trefoil inevitably produced by hammer-beam framing. But how to distract the eye from the construction's inherent bulkiness? He may well have concluded that a giant arched rib sweeping through the frame might work, similar but steeper to the one he had just completed in the tie-beam roof at Winchester Castle (Fig. 6.2).[12]

---

[12] *EMA*, xlvi. Useful accounts of the hall of Winchester Castle are Melville Portal, *The Great Hall of Winchester Castle*, (Winchester: Warren, 1899), and Martin Biddle & Beatrice Clayre, *Winchester Castle and the Great Hall* (Winchester: Hampshire County Council, 1983). The date of the roof is problematic. Biddle & Clayre suggested possible dates of 1348-9, or 1390-1404 (p. 28). Portal leant more to the 1390s (p. 64). Extensive works were certainly executed in the early 1390s: in 1391- 92 Richard II paid 13 carpenters for 74 days work; in the 13th year of Richard's reign, hall was described as 'quasi de novo constructa.' (*Foreign Accounts* 17, Rich. II, rot. Gd; *HKW*, 863-4). In 2000 two relatively minor timbers were tree-ring dated by Dr Martin Bridge (*VA*, 31). The timbers yielded a vague felling date of 1462 – 1562. According to Dr Bridge (personal

Accepting Herland's familiarity with hammer-beam construction, and putting aside his conjectured (and admittedly fanciful) musings, on a more detailed level we can observe at Winchester some of Hugh Herland's signature carpentry before it was applied on a grander scale at Westminster. Completed in the years 1387-94, the great hall at Wykeham's Winchester College features atypical medieval, but typical Herland, framing in the wall posts of the shallow-pitched tie-beam roof therein (Fig. 6.3).[13] These wall posts have a projecting 'spur' to receive arch braces of squarer than usual section (Fig. 6.4).[14] This is a technique Herland had employed a decade or so earlier in the Abbot's Hall in the precincts of Westminster Abbey (*c.* 1376), and, incidentally, he used the same symmetrical decorative motifs in the spandrels of the two structures: trefoil and twin mouchettes.[15] Herland's wall-post spur means that the arch brace meets the wall post in a manner which departs from mainstream fourteenth-century construction. In typical medieval carpentry, the arch brace is tenoned into a wall post horizontally so that the shoulder of the joint is vertical, and often no other abutment was deemed necessary apart

---

communication), a late fourteenth-century construction date 'is not rejected by the meagre dendro results' obtained from these minor timbers, but neither is it supported.

The roof was restored by T. H. Wyatt in 1873, but according to Wyatt, 'both form and scantlings had been religiously adhered to', T. H. Wyatt, 'On the Old Hall and New Assize Courts at Winchester', *RIBA Proceedings*, 1873-4, p. 160.

[13] For the date of the hall see Arthur Francis Leach, *A History of Winchester College* (London: Duckworth, 1899), 133-134; Harvey (1978), 61, 277. The present roof is 1819-20 by William Garbett, said to be a faithful replica of Herland's original; see Pevsner, *Hampshire: Winchester and the North* (London: Yale University Press, 2010), 650; *EMA*, 139; Anthony Emery, *Greater Medieval Houses of England and Wales, 1300-1500* (Cambridge: CUP, 1996), Vol. III, 421. After surveying the hall, Garbett wrote in admiration of the 'combination of excellence' of Herland's roof, its 'simple elegance …, the scientific principles of its construction, the care with which the materials must have been selected, and the accuracy with which the workmanship was executed.' He concluded that 'the circumstances appear favourable for perpetuating so venerable an example of Carpentry according to its original design', Letter, in Thomas F. Kirby, *Annals of Winchester College: From its Foundation in the Year 1382 to the Present Time* (London: H. Frowde, 1892), 42-43. Garbett, a Winchester architect, was also a scholar and architectural historian, so it is reasonable to conclude that he would have restored Herland's roof in an authentic and sympathetic manner. See Garbett's erudite letter in John Britton, *The History and Antiquities of the See and Cathedral Church of Winchester* (London: Longman & Co., 1817), 55-69.

[14] 'Spur' is my own designation for these projections.

[15] Similar spurred wall posts are found in bishop Wykeham's house in East Meon, Hampshire, *c*. 1396 (see Chap. 4). Although in the vicinity and an acquaintance of Wykeham, It seems unlikely that Herland would have supervised a roof of such conventional structure – especially while occupied with the Westminster hammer-beam. But perhaps the anonymous carpenter was familiar with Herland's idiosyncratic wall-post framing.

from the tenon (Fig. 6.5).[16] At best, the carpenter may have formed an abutment on the wall post corresponding to the depth of any moulding, but this was as much a visual as structural technique, allowing a smooth transition between timbers as the moulding flowed from one component to the other. At Winchester College, however, Herland's spur meant that the brace was framed into the wall post with its shoulder nearer a horizontal plane.

Is this a technique to ensure that the shoulder of the joint is more aligned with the direction of lateral thrust, and thus provide a more secure abutment? At Winchester clearly not, as this is a tie-beam roof and thrust is absent. Rather, Herland, pursuing elegance, intended the spur to be to be a visual device, a means of accentuating the arched rib by allowing it to flow, apparently uninterrupted and detached from the wall post, to the corbel. In a case of visual chicanery, the wall post ostensibly appears to be framed into the arch brace rather than vice-versa. Such level abutments may well have been an adaption of a technique found in structures which Herland had personally constructed: timber vaulting (see Fig. 1. 26). A smooth continuous rib, flowing from corbel (or capital), through apex, to corbel, is a visual prerequisite in a vault. The construction of ribs in the majority of vaults conveys just that appearance, although smooth lines are maintained at their springing points usually by a *tas-de-charge* in a masonry vault, and some form of spurred wall post in the timber version (Fig. 6.6). A recurring theme in this discussion of Westminster Hall will be Herland's adaption and escalation of small-scale techniques and forms to meet the demands of the massive new carpentry.

Intriguingly, the spurred wall posts of Winchester College and the Abbot's Hall were simplified versions of the wall-post framing about to be carpentered at Westminster Hall (Fig. 6.7 & 6.30). The Westminster posts have four arched timbers, again of squarer section than typical arch braces, springing from almost horizontal planes. Herland possibly adapted the, primarily visual, framing at Winchester and the Abbot's Hall to meet the more rigorous structural exigencies later at Westminster. It may well be, then,

[16] As confirmed, for example, by a perusal of Elizabeth Lewis *et al.*, *Medieval Hall Houses of the Winchester Area* (Winchester: Winchester City Museum, 1988).

that the atypical wall-post framing at Winchester College was a practice piece for the more complex framing about to commence a day's ride away at Farnham.

Having weighed Herland's competence as it stood in the early years of the 1390s and his works in Winchester, I will now discuss the application of that consummate expertise and experience when he was confronted with the largest space yet to be spanned by an English timber roof.

THE KING'S CARPENTER'S CONCEPTION OF THE WESTMINSTER HALL HAMMER-BEAM.

Hugh Herland's singular roof at Westminster has triggered inquiry and argument from the early nineteenth century onwards. Antiquarian interest began in the early nineteenth century, and investigations, archaeological, technical and art-historical continued well into the twentieth.[17] Debate has largely centred on how the roof performs structurally, with the function of the dominant - and extraordinary - arched rib the focus of most scrutiny. A squall of contention blew up in the final decades of the late twentieth century, but after the air cleared, still no consensus had been reached.[18]

At the risk of oversimplification, the warring parties were divided into two camps: those who believed that Herland carpentered a great arched rib which, performing as a 'continuous' 'rigid' arch, played a major structural role in transmitting roof weight to the corbels,[19] and those who believed that the principal rafters managed most of the roof's forces with the wall plate receiving significant loading (see Fig. 6.17).[20]

[17] For a summary of the hall's historiography before1987, including the debates regarding structure, see Courtenay & Mark, 377-387.

[18] Despite Courtenay & Mark's 1987 pronouncement that their study had 'clearly resolved' questions regarding the roof's structure (p. 374), in 1995 Toby Morris *et al*. could write that 'there is as yet no definitive analysis', 338. See also the vigorous exchange of views in the correspondence of Courtenay & Mark, Heyman and Mainstone ('Letters', *Journal of the Society of Architectural Historians*, Vol. 47, No. 3 (Sept., 1988), 321-323), and the combative tone of Waddell's 1999 paper.

[19] Courtenay & Mark, 390, 392; Toby Morris *et al*., 340, 342, 344; Mainstone (1997), 320. In order to ascertain the structural role of the various timbers, Courtenay & Mark used a 1:10 timber model, built by Yun Sheng Huang, fitted with electronic strain gauges.

[20] Jaques Heyman in 1967 contended that primary support for the roof loading comes from the wall head, and the principal rafters are the main structural members. Hammer beams and hammer posts are 'not load-bearing under a vertical dead load', and hammer beams are 'virtually unloaded', The arch rib and wall posts

In the latter case, the hammer-beam framing is largely suspended from the principal rafters. Curiously, in contrast to the arched rib, Herland's massive hammer-beam framing received comparatively little attention.

With the opinions of antiquarians, modern art historians, archaeologists and structural engineers in mind, we may now turn to the likely opinion of the King's Carpenter himself. As Herland began the prefabrication at Farnham, how did he, with his unparalleled mastery of carpentry, think that his colossal structure would function? What was his structural intention for the feature that has so preoccupied later scholars: the great arched rib? The following analysis is founded on a study of the 'Schedules', preparatory drawings executed in 1313-14 by HM Office of Works under the direction of Frank Baines, and my own reconstruction of Herland's lower framing based on those drawings.[21]

A note on the reconstruction: this was an attempt to experience the thought processes of Hugh Herland as he commenced the project. The reconstruction, carried out by myself and traditional carpenter Mr Chris Dalton, consisted of one lower hammer-beam bracket – the most complex and demanding framing in the roof - using identical jointing methods.[22] It was constructed using the same material that Herland used: green, unseasoned, oak. The first step was to visit the National Archives to study the 'Schedules.' There, numerous photographs and, most importantly, measurements were taken of the drawings (much to the consternation of the National Archives staff) in order to confirm details and obtain essential dimensions not found in Frank Baines's

---

are only useful to alleviate lateral wind-loading, 'Westminster Hall Roof', *Proceedings of the Institution of Civil Engineers*, 37 (1967), 137-162. He largely maintained this view in 1988, 'Letters', 322.

[21] Beginning in 1913, the roof was surveyed and repaired by HM Office of Works under the direction of chief architect Frank Baines (1877-1933). The 'Schedules' are detailed preparatory drawings executed to facilitate the work. The bound volume of the 'Schedules' is National Archives: 'Works' 29 / 3299 (another copy is held in the Parliamentary Archives at Westminster). 'WORKS' 29 / 3419-3597 contains further elucidatory drawings made by Baines's office during the restoration of the roof.

[22] The author has some experience as a traditional carpenter, but the reconstruction of the lower framing could not have been accomplished without the craftsmanship and patience of Mr Dalton.

published *Report* or Cescinsky and Gribble.[23] On commencing the framing, the first discovery was that the complex framing lived up to expectations: it was *extremely* difficult to carpenter. The carpentry techniques, especially where the four arched timbers meet the wall post, radically differed from any framing of our experience. Initially, much time was spent just in puzzlement and wonder at how Herland devised this unique contignation. The three-dimensional spatial imagination necessary to design the configuration is extraordinary. To envisage merely the form of the wall post in a freshly cut log demanded an eye akin to that of a sculptor. Nevertheless, the reconstruction was completed to our satisfaction, and the experiment enabled us to derive valuable insights into probable erection procedure, economic and adaptable use of timber resources, and into how Herland (rather than twentieth-century structural engineers) thought the roof would perform. Many of these insights inform the conclusions expounded in the subsequent pages.

The span Herland was confronted with in Rufus's old hall was wider than in any northern European building then constructed (see Fig 5.1). Roofs of wider span existed in southern Europe, for example in Padua, the Pallazzo della Ragione of the early fourteenth-century with a span of around 90ft (27.5m). Such roofs, however, were the product of a different carpentry tradition. Firstly, they utilised pine, which, as anyone who has taken a walk in both a pine forest and an oak woodland will know, is naturally available in straighter and longer lengths than oak.[24] Secondly, these tie-beam trusses only function because they formed of composite timbers and are bound together by an assortment of ironmongery.[25]

---

[23] Frank Baines, *Report ... on the Condition of the Roof Timbers of Westminster Hall* ... (London: HMSO, 1914) (henceforth, Baines, *Report*). Herbert Cescinsky; E. R, Gribble, *Early English Furniture and Woodwork* (London: The Waverley Book Company Ltd., 1922), Vol. I, pp. 100-1.

[24] See my comments on the growing properties of oak in Appendix 2 of this thesis.

[25] See Christopher Wilson, 'Rulers, Artificers and Shoppers: Richard II's Remodelling of Westminster Hall, 1393-99', in Gordon, Monnas & Elam (eds.), 1997, p. 55, nt. 98, for Padua and other wide span European roofs, for example, the Sala de Maggiore Consiglio, Venice (*c*. 1362-66) at 25m.

In considering the challenge of such a vast span of nearly 69ft (21m), Herland must have dismissed a number of options at the conceptual stage.[26] Oak tie beams of around seventy-five feet in length (to allow them to sit securely on the wall head), each weighing approximately twelve tons, would have been impossible to source, constructionally inconvenient and aesthetically unthinkable.[27] In an age of the open 'display' roof, Richard II would demand its apotheosis, both visually and technologically. Crucks, including base-crucks, of such massive dimensions would similarly be impossible to locate, and besides, full crucks perhaps smacked of the rustic.[28] An arch-braced roof is an attractive open roof form, and was being used to adorn fourteenth-century buildings of prestige. But arch-braced trusses are inherently poor at resisting lateral thrust, and to span the enormous space at Westminster with such a structure would be unconscionably risky.[29] The hammer-beam roof was Herland's only option: the hammer-beam supplies aesthetic possibilities not found in other frames; it is a form of structure which inherently uses shorter timbers, thus ameliorating timber supply problems; and, as a system of buttressed opposing brackets, it offers a degree of structural stability.

It should also be remembered that Herland was attempting something beyond the scope of the mason. As we saw in Chapter 1, following the collapse of the crossing tower

[26] My own measurements of the span of the hall: south end: 68ft 6in (20.88m); midpoint: 68ft 3in (20.80m); north: 67ft 5in (20.55m), (measured with a Bosch GLM 80 laser rangefinder). The hall, then, tapers from south to north – a further problem for Herland to contend with.

[27] Baines, *Report,* 25, 26. Green English oak weighs around 720kg per cubic metre, Peter Ross *et al*., *Green Oak in Construction* (High Wycombe: TRADA: 2007), 24. See my comments on the availability of large timbers in the Middle Ages in Appendix 2 of this thesis.

[28] The largest cruck building in existence is Leigh Court Tithe Barn, Worcestershire (1344d) which has a span of just 33ft 6in (10.2m); see N. W. Alcock, *Cruck Construction: an Introduction and Catalogue* (London: Council for British Archaeology, 1981), frontispiece, 27; also F. W. B. Charles, *The Conservation of Timber Buildings* (Shaftsbury: Donhead, 1995), 48-50; Anthony Emery, *Discovering Medieval Houses* (Botley, Oxford: Shire, 2007), 77.

[29] Baines, *Report*, 27. See Thomas Morris for a nineteenth-century understanding of the futility of the pegged tenon in tension, *Brief Chapters on British Carpentry* (London: Simpkin, Marshall & Co., 1871), 76; and David Yeomans, *How Structures Work* (Oxford: Wiley-Blackwell, 2009), 111, for a twenty-first-century appreciation. In the seventeenth-century, tie-beams had to be inserted to control lateral thrust in the fifteenth-century arch-braced roof of St Mary's, Tunstead, Norfolk; see D. P. Mortlock and C. P. Roberts, *The Guide to Norfolk Churches* (Cambridge: Lutterworth Press, 2nd ed. revised, 2007), 295. From my own experience: a green oak arch-brace truss completed by Timber Framing & Conservation of Leicestershire in 2011, despite its full complement of pegged mortice and tenon joints, was only passed by the consulting structural engineer as safe when it included three-way high tensile steel tie-rods.

of Ely Cathedral, it was the carpenter, not the mason, who was turned to in order to span the void of the octagon. The widest span bridged by an English mason before Westminster Hall was the 46ft (14m) or so of the Lady Chapel at Ely (1322-49), a mere two-thirds of the span Herland had to contend with. It may be that for the new open space desired by Richard II for Westminster, the carpenter was simply a 'Hobson's choice.'

AN INNOVATIVE AND RARE TECHNIQUE

At this point, in what may appear a digression, I will introduce an unusual carpentry technique Herland used extensively throughout the Westminster framing. Its relevance will become clear shortly. Herland, in carpentering such a massive structure, evidently wanted to avoid using, or had difficulty sourcing, timbers of massive section. Thus, the timbers of the main purlins and collar beams are composite, of two parallel longitudinal components (Figs. 6.7 & 6.8).[30] Obviously, high-performance adhesives were unavailable to Herland for him to laminate these important structural members, so he had to devise an alternative technique. Following his survey of the roof in 1913/14, Frank Baines called the chief components of this technique 'keys', but this prosaic term fails to do justice to what is an ingenious constructional device (Fig. 6.9; also 6.33). In order to bind the timbers together, Herland cut a series of corresponding mortices in the two timbers. The mortices in one timber he made wider, and he dovetailed them on one side, *viz.* the mortice is wider at the bottom than at the top. The mortice in the opposing timber is cut conventionally square. To fit these mortices, Herland created 'keys' or 'loose' tenons. One side of the key is square to fit the orthodox mortice, the other dovetailed to fit its counterpart, but narrower than its mortice. With the key inserted, this discrepancy allows a packing piece to be inserted which forces the dovetailed tenon against the corresponding end of the mortice. Once the packing piece is in place, the tenon cannot

[30] Baines thought that the main 'trussed' purlin originally consisted of three timbers: two main structural timbers and a decorative cornice (see fig. 6.6). Other timbers are later additions, *Report*, 23, 70. For the collar- beam see *Report,* 19-20. At 40ft (12.19m), the collar-beams are the longest timbers in the roof.

be withdrawn. The opposing timber may now be fitted conventionally to the protruding square tenons. Once these conventional square tenons are draw-bored (see glossary) and pegged, the packing piece is secure, and so is the dovetailed tenon. Thus, Herland locks together two or three timbers of modest section to form one timber of massive section.[31]

I have discovered no other examples of this practice. As carpenters understood the utility of the dovetail, related techniques came into existence: the door to the Pyx Chapel in Westminster Abbey (1032-64d) is ledged with housed timbers dovetailed at both ends.[32] In France, the carpenter of the barn at Saint-Lazare de Beauvais, Oise (1219-20d), dovetailed his king post into the tie beam via an oversized mortice, a mortice which allowed the packing piece to be inserted which locked the dovetail into place (Fig. 6.10).[33] A more direct parallel to Herland's keys can be found in a wreck, dating from the third or fourth century, found submerged on the banks of the Thames in London.[34] In a boatbuilding technique, here the craftsman employed pegged loose tenons to join the planking of the hull (Fig. 6.11). His keys, however, are not dovetailed, and neither are they combined with the oversized mortice and packing piece. The specific technique used by Herland at Westminster seems, therefore, a unique expedient designed specifically to cope with the demands of the colossal Westminster carpentry.

THE FRAMING OF THE GREAT ROOF: FIRST CONSIDERATIONS

Putting aside Herland's keys for now, I will now look at how Herland approached the framing at Westminster. His conception, particularly of the great arched rib, is crucial to understanding how Herland thought the roof would perform. Did Herland intend the

[31] Herland certainly used loose tenons to bind the collar beams, but Baines is unclear whether these are dovetailed or not. Herland pegged them from both sides, which may either connote that they are not dovetailed, or it was a belt and braces approach to the melding of this important structural timber; Baines, *Report*, 19.

[32] Illustrated and discussed in *EHC*, 25-26.

[33] Frédéric Épaud, *De La Charpente romane à la charpente gothique en Normandie: l'évolution des techniques et des structures de charpenterie du XIIe au XIIIe siècles* (Caen: Publications du CRAHM, 2007), 234.

[34] Seán McGrail, *Ancient Boats and Ships* (Princes Risborough: Shire, 2nd ed., 2002), 38, 42-43; *Ancient Boats in North-West Europe: the Archaeology of Water Transport to AD 1500* (London: Longman, 1998), 103, 135.

roof to function as a conventional hammer-beam, or was there, in the audacious great rib, an attempt at unprecedented carpentry in order to manage the forces in this unprecedented roof?

To begin to understand the roof, it is advantageous to start with the most conventional part: the upper framing. Here one finds a king-post roof (Fig. 6.12). The king post (and, for taxonomical purists, supporting a ridge, a king *post* it is) is framed by double tenons into a cambered collar beam and rises to a ridge.[35] A significant detail is that, in order to receive the principals, the top of the king post is joggled (Fig. 6.13). I will return to this detail shortly. The king post is flanked by a two queen struts, framed into the principals, and a pair of horizontal timbers connect these verticals. Apparently, then, nothing too avant-garde here. Of note, however, is that the king-post framing forms an autonomous, independent roof structure. Indeed, the whole of the upper structure could be removed and placed upon masonry walls for it to function perfectly adequately without any underlying hammer-beam carpentry. What were once collar-beams would be tie beams. Understanding this orthodox construction of the upper roof is crucial for interpreting how Herland thought the Westminster roof would work. In essence a tie-beam roof, this upper structure exerts no lateral thrust.[36] Herland must have thought, therefore, that the roof weight must travel directly down the hammer posts, just as the weight of any tie-beam roof of his vast experience would have travelled vertically down timber wall posts or masonry walls. Diagonal bracing, arched or otherwise, principally served to counteract any lateral racking caused by wind loads or settling of the frame.

Herland's orthodox approach to the function of the upper roof is mirrored by further orthodoxy in the upper hammer-post framing at the point where those posts receive the upper roof. As revealed by the schedules, the carpentry here is complex: a three-way, multi-timbered joint of collar beam, hammer post and main purlin (Fig. 6.14). To ensure the integrity of this crucial joint, Herland remained in conservative mode, and

[35] Although this timber may well originally been a king 'strut': Baines thought the ridge was not an original timber; Baines, *Report*, 24.
[36] Baines, *Report*, 24, 29.

framed a variation on the time-honoured English tying joint in normal assembly (see glossary) – a routine, unremarkable joint for him. Employing this joint in this situation, as did the carpenter at Pilgrims' Hall, again demonstrates that Herland's approach was rooted in post and beam tradition, rather than any highly experimental framing dependant on a great arched rib.[37] Indeed, during his initial surveys at Westminster, Herland had a model of aisled construction right before him, in the form of William Rufus's old hall (Fig. 6.15).[38] It is tempting, and not altogether preposterous, to imagine Herland experimenting with Rufus's old structure, perhaps sawing out a couple of opposing posts to see how the frame would react. Herland had seen how the carpenter of Pilgrims' Hall had employed traditional, braced post and beam, techniques to transform aisled structure and create one of the earliest hammer-beam roofs. In similar manner, at Westminster he relied upon traditional, trusted carpentry methods which had served him throughout his distinguished career.

Herland's arrangement of the main 'purlin' and the lower principal is further evidence that his design approach was rooted in post-and-beam tradition. The term 'purlin' is something of a misnomer. Composed of two main timbers, locked together by Herland's dovetailed keys, this 'purlin' is set orthogonally to the ground, *not* in the plane of the roof (Figs. 6.8 & 6.16).[39] It performs, then, the function of the arcade plate found in traditional aisled structures: as a timber to sustain the common rafters and to affix longitudinal bracing rising from the posts. Furthermore, the lower principal rafter, framed into the top of the hammer post by a substantial double tenon, functions like the 'shore' in any traditional aisled carpentry, and, indeed, the Pilgrims' Hall hammer-beam (Fig. 6.16).

[37] The CBA (G2) prefer the term 'box-framing' for this type of carpentry. I prefer 'post and beam' here because the term more aptly evokes the construction, and, I think, is more applicable when referring exclusively to roof carpentry.

[38] Conventional scholarly opinion is that William Rufus's hall of 1099 was aisled with a central nave, although this has view has recently been challenged. For my own exposition of why I think the hall was aisled, see Appendix 2 of this thesis.

[39] Baines, *Report*, 23, 70. Baines thought that the main 'trussed' purlin originally consisted of three timbers: two main structural timbers and a decorative cornice (see figs 6.8 & 6.9). Other timbers are later additions.

Herland, then, in conceiving the Westminster framing in such an orthodox, braced post and beam, manner, was similarly thinking of the hammer posts in an orthodox manner, as truncated arcade posts. Just as arcade posts are the principal timbers for transmitting the weight of the upper structure vertically, Herland would have had similar intention for the hammer posts. The vertical and lateral deflection of the hammer beams, as found by Baines throughout the roof, indicates that the hammer posts were indeed transmitting a large degree of vertical weight.[40] Further, if Herland followed earlier fourteenth-century hammer-beam designs, for example Pilgrims' Hall, he would have cambered the hammer beams, meaning that subsequently found deflection was even greater.

If I seem to have laboured the point that Herland's structure is that of orthodox post-and-beam construction, the above interpretation of the role of the hammer posts is at variance with late twentieth-century analyses of the roof. Undertaken from an engineering standpoint, such studies include a paper based on computer analysis of the reaction of timber models to assumed loads,[41] and a paper which applies 'finite element analysis' to the structure.[42] A common conclusion of these inquiries is that loading, initially proceeding from the upper king-post roof down the hammer post, deviates and continues down the arched rib, through the centre if the hammer beams, and on to the corbels (Fig. 6.17). The ends of the hammer beams, then, receive little of the upper roof weight. Such diversion of forces, independent of any external factors such as wind loading, might well be how the roof behaves under certain conditions and assumptions, but it would have been baffling to Herland, just as it would to the builders of Stonehenge and to any child playing with building blocks. Herland surely did not think that the majority of the weight of his tie-beam roofs at the Abbot's Hall and Winchester College

[40] Baines, *Report*, 30.
[41] Courtenay & Mark (1987).
[42] Toby Morris *et al.*, 336-347. Enlighteningly, the authors explain 'finite element analysis' thus (p. 338): 'Finite element analysis breaks down any structural system… into submembers (such as individual truss members or discrete segments of a continuous vault). Computer algorithms then utilize the spatial information locating these discrete elements and the mechanical properties of their materials to assemble a comprehensive model so that an overall structural evaluation can be made.'

was somehow converted into diagonal thrust. Consequently, neither building is reinforced by substantial masonry buttressing (Fig. 6.18).[43]

The conclusion of the modern scholars that the arched rib communicates much of the upper roof weight may be explained by an assumption made by the later investigators. The computer modelling assumes the arched rib is receiving a degree of the upper roof weight from a midpoint on the collar-beam. This, however, presupposes that the king post is resting on the collar beam and thus under compression from its own weight and that of the rafters. Rather, in a reversal of such structure, Herland may have considered, as did many of his French contemporaries, the king post to be a tensional member, and thus the collar beam to be suspended via the king post from the principal rafters (see Fig. 3.22).[44] The joggling of the king post was mentioned earlier. Such a faceted termination may indicate that Herland intended just such a structure: the principals to prop up the king post rather than vice-versa. If Herland's king post is tensional, then the centre of the collar beam would be suspended from the king post, and their combined weight would be transmitted to the foot of the compressive principals. From there, forces would continue to the tops of the hammer posts, and continue vertically down those hammer posts. Little of the weight of the upper roof, therefore, would be transmitted onto the arched rib via the collar-beam as suggested by computer modelling. In a further refinement which would limit any bending of the beam onto the arched rib, Herland ensured that the collar beam was cambered.[45]

---

[43] For the exterior of the hall of Winchester College see unnumbered plate in R. Custance (ed.), *Winchester College: Sixth-Centenary Essays* (Oxford: OUP, 1982).

[44] As Patrick Hoffsummer has shown, the first instances of northern European carpenters suspending tie beams via king posts from the apex belong to the twelfth century. By 1220d, and the construction of the nave roof of Notre Dame Paris, carpenters were developing elaborate roof systems with 'hanger' king posts as key components, *Roof Frames from the 11th to the 19th Century: Typology and Development in Northern France and in Belgium* (Turnhout, Belgium: Brepols, c.2009), 168, 174, 183, 185. See also Épaud, 185, 188, 213. English carpenters did not seem to think of vertical timbers as being suspended, although evidence of such intent may be found in the queen posts of the roof of the Angel Choir, Lincoln Cathedral (mid thirteenth-century), where the posts are dovetailed into the tie beam; and in similar timbers in the roof over the north transept of Tewkesbury Abbey (possibly mid fourteenth-century); see Cecil Hewett, *English Cathedral and Monastic Carpentry* (Chichester: Phillimore, 1985), 31-32, 35-36.

[45] Admittedly, while a visual device, the cambering of the collar-beam may also indicate Herland thought the timber subject to bending.

An important interpolation here is that Herland's refinement at the top of the kingpost seems to be the first instance of a 'joggled' king post in the history of English carpentry.[46] A comical appellation belies the structural importance of 'joggling.' Its structural utility is twofold: the rhomboid termination permits more timber into which the compressive principals can be tenoned, thus strengthening the connection, and the inclined shoulders of the joint assist in the propping of a tensional king post. As later carpenters realised its utility, the joggled king post became a standard and widespread modification in post-medieval carpentry, and it continues to be used widely to this day.[47] By this easily overlooked detail, Herland rendered a roof of apparently orthodox construction both innovative and influential.

We have reasonably established, therefore, that Herland, in conceiving the Westminster framing, was thinking conservatively, in terms of braced post and beam carpentry. His matchless empirical knowledge told him that the weight of the upper independent tie-beam roof would travel down through the hammer posts to be received by the hammer beams, thence to be transmitted to the masonry walls by the lower hammer-beam framing. What, then, did Herland think was the function of one of the dominating forms of the great roof, the arch rib?

THE DESIGN CONCEPT BEHIND THE GREAT ARCHED RIB (OR, HUGH HERLAND: ARCH DECEIVER?)

> 'The function of this member is rather difficult to determine.'
>
> Frank Baines, 1914 [48]

[46] I have consulted all known pictorial sources for English medieval carpentry in general, and for king-post roofs in particular. I can find no earlier example of a joggled king post than Herland's 1393 usage. Earlier European examples can be found, see Épaud, 189; Hoffsummer, 174.

[47] See Joseph Moxon, *Mechanick Exercises, or The Doctrine of Handy-Works* (London: 1703), 145; Thomas Tredgold, *Elementary Principles of Carpentry* ... (London, John Weale, 3rd ed., 1840), pl. V, fig. 49, pl. VI, fig. 51, pl. IX, fig. 62, pl. X, fig. 66; Rupert Newman, *Oak-Framed Buildings* (Lewes: The Guild of Master Craftsman Publications Ltd., 2005), 49.

[48] Baines, *Report*, 32.

Frank Baines (later to be knighted) was a professional of experience and expertise in matters of architecture and structure, and he came to know Herland's roof better than anyone.[49] Cautionary, therefore, is his modest remark to scholars intent on making cocksure assertions regarding the function of one of the predominant features of the Westminster roof, the great arched rib. Nevertheless, with Baines's words in mind, by approaching the structure from the standpoint of Herland the carpenter, further insights as to how the arched rib was intended to function may be posited.

In order to understand the function of Herland's arched rib, it is vital to be conversant with its structure. While to the observer the great rib appears to be a massive solid timber sweeping, uninterrupted, through the roof, when viewed in section it is immediately recognised as consisting of five timbers framed together which form a **ᴜ** (Fig. 6.19 & 6.20). The five timbers are arranged as follows (dimensions before moulding): a central core measuring 8½ x 12 inches (215 x 305mm); two outer laminates, each 8 x 12 inches (202 x 305mm); two mouldings approximately 7¾ x 4⅝ inches (197mm x 119).[50] The mouldings are non-structural. A point to note relating to these dimensions is that, in addition to being of lighter section than the core timbers, the two outer laminates are more heavily moulded. Indeed, due to this ornamental concern, they lose approximately one-eighth of their original section. By contrast, the section of the core timber is less excised by moulding, especially in the lower framing below the hammer beam, at which point the core is a significantly heavier timber. Here, therefore, even at this initial stage of our analysis of the great arched rib, contained in these scantlings is a clue to the relative structural roles Herland ascribed these three main timbers.

The next thing to note is that Herland, in using a composite **ᴜ** profile, and not joining the timbers together in the same plane, did not intend the great rib to function as a solid timber arch.[51] As further evidence, he merely face-pegged the laminates to the core, and when Baines inspected the roof in 1913/14 he found many of them to be

[49] Courtenay & Mark, 381.

[50] Baines calls these outer timbers 'ribs'. For clarity I have decided to designate them 'laminates.'

[51] Viollet-le-Duc considered the arched rib to be a rigid monolithic structure; see Courtenay and Mark's comments on his appraisal, 380.

detached, 'springing' away from the central core.[52] Here, we come to the significance of Herland's dovetailed keys. Herland knew that his green oak would warp and twist as it dried out. If he was concerned that the arched rib would maintain its integrity and its components function as a solid unit during this process, surely he would have paid greater attention to their joinery. He could have employed the pegged keys to lock the timbers together as in other components – the main purlin and the collar-beam – timbers he evidently did judge as important and worthy of the trouble.

Continuing to focus on of the outer laminates, it is to be noted that they are composed longitudinally of six segments (three per side) (Fig. 6.16 & 6.21). If Herland intended these timbers to serve the same structural function as six segments of a pointed arch resisting compressive forces, he would have connected them in a different manner. To obviate any danger of hinging (which is how arches often fail), the joints that longitudinally connect these members ought to have been more sophisticated. The scarf joint Herland used to link the segments, though, is modest: a simple bridle joint. To counteract any leverage placed on this joint by any tendency to hinge, Herland, at the very least, ought to have made the tenons and bridles of the joint longer. As a carpenter, however, Herland would know that to obviate the leverage of hinging, a face-halved bladed scarf would have been better practice (Fig. 6.22). As this joint was not used, hinging was not a primary concern, and so Herland cannot have been thinking of the laminates as a continuous arch. Furthermore, a flaw in the analysis of Courtenay & Mark is that the simple bridled scarf joints are not replicated in their model. Their laminates are continuous timbers, and hence their rib must indeed function to some extent as a 'continuous' arch. The resulting structural conclusions from their analysis would have left Herland nonplussed.[53]

Remaining with our analysis of the outer laminates, further carpentered evidence also reveals that Herland did not intend these timbers to function as part of a continuous

[52] Baines, *Report*, 19.

[53] Courtenay & Mark, 388. Yun Sheng called his model 'a reasonable close facsimile of the prototype', 12. He also concluded that the 'great arch rib … acts as a *continuous* member to convey much of the vertical dead load and horizontal thrust', 15 (Italics his).

arch. As became apparent during our reconstruction, the laminates, which appear to run continuously through the main vertical and horizontal members - hammer beam and hammer post - on inspection do not. They are cogged (see glossary; Baines calls it 'halved') over the post and beam (Fig. 6.23 & 6.24).[54] From Baines's Schedules it appears that such cogging, combined with the section of the core timbers, approximately doubles the effective surface acting as a compressive stop.[55] Thus, the laminates of the great arched rib possess some strutting function homologous to typical arch braces in orthodox carpentry, and a further detail confirms Herland's orthodox bracing intent behind the laminates.

At the point where they pass over the hammer beams, the laminates narrow to form a notch (Figs. 6.25 & 6.26).[56] Herland, in creating this notch rather than running the laminate straight though the hammer beam, evidently intended the laminate to strut the hammer beam. An important distinction is that Herland did not notch the laminate over the hammer *post*, so he must have intended this strutting or supportive role for the laminate specifically at its conjunction with the hammer *beam*. This shows that, for Herland, the hammer beam was the key structural component. As further evidence of the hammer beam's centrality to the structure, Herland, by cogging and notching the

[54] Schedule 29a clearly shows the laminates cogged over the hammer *post*, but, because of the perspective, similar confirmatory detail on the hammer *beam* is obscured. In our reconstruction we decided to cog the laminates over the hammer beam because, (a) Baines uses same virtually the same term to describe the framing at the two points: 'the outer arch ribs halve with… the hammer post', 'the [outer] ribs are halved with [the hammer beam]'; (b) Herland used the technique on the hammer posts, timbers which have the largest section of any component in the roof. The hammer posts would thus seem the timbers with most capacity to accept the full section of the outer laminates, yet Herland, by cogging, preferred to leave sectional timber on the posts, rather than the laminates. Logically, he would have done the same on the smaller section hammer beams. (c) Similarly, leaving the laminates in their full section (uncogged) at their intersection with the hammer beam would entail removing two thirds of the section of the beam. The hammer beam at this point is already weakened by the core timbers entering from above and below, and the section would later be further diminished by heavy moulding. Pondering these factors for our reconstruction, and convinced that Herland thought the hammer beam a key structural timber, we concluded that to remove so much material from the beam would have been, for him, unconscionable.

[55] The cogging of the laminates goes some way to assuage Waddell's doubts regarding the bracing capacity of the core timbers, 59.

[56] It is unclear whether Yun Sheng's model in Courtenay & Mark contains the cogging, one suspects not, but the laminates clearly do not narrow at the intersection with the hammer post and beam. Courtenay & Mark, 388, describe the outer laminates as being 'continuous across the intersections.'

laminates at this critical point, reduced their sectional dimensions by approximately one-half (Fig. 6.24), while retaining timber in the hammer beam. Such framing demonstrates the structural priorities Herland was assigning to these timbers. Would he have reduced the dimensions of the laminates so drastically if he thought the arch was behaving continuously in transmitting loads from higher in the roof? The cogged and the notched laminates evidence again that Herland was not thinking in terms of a continuous arch, but, to reiterate, in terms of conventional, braced, post and beam construction, with the hammer beam as a key structural timber.[57]

While acknowledging a limited structural role for the laminates at this point, a final detail of their framing again indicates that Herland was not thinking of these timbers as chief structural components. The central core and the 'curved strut' (see Fig. 6.7 for Baines's nomenclature here) are morticed onto the wall post. By contrast, the laminates are merely face-pegged to the post with one peg (Fig. 6.27). We have seen earlier how the laminates fixed thus have a tendency to spring away from the central cores. Yet this seemed of little concern to Herland, even at this seemingly crucial point where the laminates meet the wall post and any compressive forces have to be received. Techniques existed which would have compensated for the lack of a mortice and tenon. To prevent the laminates springing away from the wall post, Herland could have under-squinted the terminations of the laminates. Under-squinting (Fig. 6.28), a technique found in contemporary scarf joints used to prevent similar springing apart in longitudinal timbers, would have been familiar to Herland. Nonetheless, he elected not to use a relatively simple expedient, apparently deeming it unnecessary at this apparently crucial juncture. Herland, then, clearly thought these laminates, and thus the great arched rib, had a lesser structural role than that ascribed it by later scholars.

Before concluding this discussion on Herland's structural rationale for the rib laminates, one final point ought to be adduced regarding the nature of Herland's raw

[57] Courtenay & Mark concluded that, 'It is mainly the *rigidity* of the *continuous* arch that allows it to transfer much of the roof loading to the corbels', 390, also 392. The study by Toby Morris *et al*. concurred: 'axial or compressive forces in the main members run primarily through the extremely large and *stiff* great arches to the corbel stones', and 'the *extremely stiff* arch is responsible for discharging most of the roof's loads to the corbel stones', 342, 344. (Italics mine). See also, Yun Sheng Huang, 15.

material: ‘green’ oak. The oaks Herland used may have undergone a minimal amount of seasoning, but they were still moisture laden. As such, as they dried out in the subsequent decades they would twist, warp and perhaps most importantly, shrink. The knowledge that his material would inevitably shrink would have been basic to even the most simple village carpenter. Fundamental to the stuff of the King’s Carpenter’s knowledge, it would have been an understanding Herland incorporated into his framing decisions. Herland would not have known the precise figures as established by modern engineers, but green oak shrinks tangentially by about 7% from ‘green’ to the average ambient humidity. The laminates are 12 inches (305mm) wide, meaning that these timbers could shrink by over ¾in (21mm) in just a few years in a building whose intended life must have been a few centuries. Aside from decoration, one of the reasons for mouldings applied to medieval timbers in general, and to the laminates in particular, was to cover unsightly gaps which would inevitably appear. Consequently, no matter how accurately the joints were cut at Farnham, shrinkage would inevitably loosen the fit. Those simple bridled scarf joints connecting the laminates, discussed earlier, would inevitably shrink and become loose, reducing the capacity of the rib to behave in any rigid, continuous manner. Shrinkage would equally occur in the laminates as they intersect the hammer post, leaving the contignation there subject to rotational forces. Herland knew all this, and he would not have conceived this joint as the ‘rigid moment connection’ described by Toby Morris and his colleagues.[58] Herland’s laminates were probably working loose even as Henry IV was declaring Richard II’s deposition in the late autumn of 1399. Modern scholars, with their ‘stiff joints’, rigid connections and continuous arches, pay little cognisance to these facts.[59] Courtenay & Mark reached their structural conclusions via an electronically rigged 1:10 test frame – constructed of ‘well-cured oak’ with apparently with tight joints.[60]

Turning now to the central core timbers in the arched rib, neither are these timbers intended to function as a continuous arch: the central core is tenoned *into* the

[58] Toby Morris *et al.*, 340.

[59] Toby Morris *et al.*, 340, 342.

[60] Courtenay & Mark, 387.

hammer posts and hammer beams – not vice versa (Figs. 6.23, 6.24, & 6.29). Thus, post and beam interrupt the continuum of these core timbers. Such carpentry is again rooted in fourteenth-century orthodoxy. The cores are mortice and tenoned into vertical and horizontal timbers just as any fourteenth-century braces. Nevertheless, the positioning of the cores does depart from fourteenth-century bracing tradition. The upper core springs proportionately from a higher point than any arch brace on a conventional arcade post or hammer post, and as a result it approaches the collar-beam more obliquely. This is an anomalous design, but to accommodate the oblique angle, the rib's bracing duties are shared with the upper 'curved strut', which springs from a more orthodox point.

Details in the way Herland handled the upper core framing further indicate that he thought of the cores as primary *bracing* components. At the point where the upper core is framed into the hammer post, he improved on a standard mortice and tenon joint by notching the hammer post concordant with the full thickness of the core, and forming a corresponding projection on the core (Figs. 6.21 & 6.23). This refinement creates a type of 'shouldered' joint, and it considerably improves the performance of the joint: (a) any shearing force the timber may develop now bear on this more substantial section rather than on the edge of a thin tenon; and (b) the shoulder significantly limits any tendency for the core timber to twist.[61]

Moving down the frame, the core from hammer post to hammer beam is an atypical component. It may represent structural insurance on the part of Herland, his doubling of the shore, or 'down' brace, formed by the lower principal rafter. Its low placement and the presence of the massive lower principal indicate, however, that Herland may have inserted it mainly as a visual device. Structurally, the core at this point could have been omitted without catastrophe, but Herland inserted it to connect the rib timbers and to complete the arc of the rib.[62] After the attachment of the laminates and moulding, to the observer the great rib would appear to flow continuously.

[61] Notching the joint thus, may also have had the intention of allowing the moulding to run uninterrupted through the timbers, but as Baines's drawing shows, the projection is greater than any depth of moulding.
[62] Waddell, 63.

By contrast, the lowest core timber, springing from the wall post to hammer beam, is a vital structural timber. For once, the framing here is unorthodox and innovative (Fig. 6.30 & 6.31). Compared with other medieval hammer-beam roofs, the rib at this point forms an additional component between wall post and hammer brace, and, significantly, Herland ensured that the timbers meet the hammer beam at its midpoint. The carpenter George Ellis thought that the rib framed thus provided 'a fulcrum whereon the hammer beams are poised, the weight of the lower part of the roof acting as a counterpoise to that of the upper, brought down to the inner end of the hammer beam by the hammer … posts.'[63] In other words, the weight of the principal rafters and their attendant purlins formed a counterbalance to the weight sustained by the hammer posts, with the lower part of the arched rib – the core and the cogged and notched laminates – as their fulcrum. Baines restated this view, though he thought this framing complicated Herland's design,[64] while Courtenay & Mark thought Herland's arrangement here perhaps a design flaw.[65] Nevertheless, the carpentry at this point is ingenious and crucial to the way Herland thought the roof would function. It will be returned to shortly.

To précis my comments on Herland's intent behind the great arched rib thus far: the rib, especially the cores, has some structural function, not as any continuous arch, but as an assembly of discrete components: braces, homologous to those in any orthodox post and beam carpentry of Herland's experience, and analogous to the structure of Pilgrims' Hall. Their atypical placement is to facilitate the form of the great arched rib. The laminates specifically, while having some 'belt and braces' strutting function, exist mainly to provide a more substantial, and thus more visually dominant, rib. The reasons why Herland was in pursuit of such a visually dominant arcuate form will be discussed in the following chapter.

---

[63] George Ellis, *Modern Practical Carpentry* (London: Batsford, 1st ed., 1906), 97. Such structural intent was less elegantly alluded to earlier by Thomas Morris, *Brief Chapters on British Carpentry: History and Principles of Gothic Roofs* (London: Simpkin, Marshall & Co., 1871), 50.

[64] Baines, *Report*, 18, 30.

[65] Courtenay & Mark, 384.

IF NOT THE ARCHED RIB, THEN WHAT SUSTAINS HERLAND'S ROOF?

Components not as yet examined are what Baines calls the 'curved struts' (Fig. 6.7). Often neglected in discussions of the Westminster roof, these components spring from base of wall post to the hammer beam, and from hammer post to upper arched rib, and they are analogous to the arch-bracing in conventional hammer-beam roof. Visually, these are the timbers which lend the trefoil form to the roof. Sectional dimensions of the curved strut are as those of the core of the arched rib: 8½ x 12in (215 x 305mm), and, as I have argued, Herland expected timbers of such scantling to perform important bracing duties. Baines, and in turn Waddell, thought these components too slender in scantling to be of structural use.[66] But what was Herland's design intent behind these components?

The longest, upper, section of the rib core of identical section is approximately 20ft (6.1m) in length, while the lengths of the lower and upper curved struts are approximately 13ft (3.96m) and 10ft 6in (3.2m) respectively. Consequently, the first thing to note is that the curved struts are relatively of short length; indeed, due to Herland's custom of framing arch braces onto level-shouldered spurs, shorter than they appear. From the hammer post, the struts rise to be framed into the arched rib rather than the collar-beam, and in the lower bracket, they terminate well short of the end of the hammer beam, and spring high on the wall post. These, then, are relatively short timbers – proportionally around two-thirds of the length of their counterparts, the hammer braces, in a typical fourteenth-century hammer-beam frame.[67] Any bending and buckling tendencies must therefore be reduced. Further, unlike the rib laminates, they are morticed into the wall post and hammer beam. The joint at the hammer-beam is also fully housed to the full depth of the strut's scantling. All the above details denote that Herland intended the curved struts as significant compressive members.

---

[66] Baines, *Report*, 30, 32; Waddell, 56, 61.

[67] The ratio of hammer-beam length to hammer-brace length at Pilgrims' Hall is approximately 6:7. At Westminster it is 4:3.

Keeping the curved struts in mind, comment has often been made about the massive scantling of the hammer post.[68] It is by far the heaviest timber in the whole roof, and one may question Herland's decision to make this timber larger in section than the hammer beam. Intuitively, one would assume that the timber providing the support, the beam, would be the largest member. Such doubts can be reconciled, however, if the upper curved struts are acknowledged as having a more prominent structural role. The massive section of the hammer post allowed the spur to be created, into which the curved strut is framed and thus shortened.

Further evidence that Herland viewed, at least the lower curved strut, as an important structural timber is exhibited in the method by which he framed it to the wall post. Here we return to Herland's pegged, dovetailed keys. As the core, the curved strut is morticed to the wall post, and one may think, as the strut is inevitably being forced against the wall post by the diagonal forces transmitted from the end of the hammer beam, this would suffice. But, as we explored by our reconstruction, Herland went further and framed the curved strut to the rib core by means of the dovetailed key (Figs. 6.32 & 6.33). Not only does this detail lock the strut to the core – a critical timber – but the key's position shortens the strut's unassisted length by around one-fifth. These already relatively short lower struts are, then, even shorter than they appear, and concomitantly any tendency to buckle must be further reduced. It is difficult to see any other reason why Herland would instruct his carpenters to cut this time-consuming joint unless he considered the curved strut a vital structural timber needing this extra surety.

Nevertheless, the lower curved struts do appear to be rather slender for the structural duties demanded of them. Perhaps visual motives were the driver: Herland may have remembered the heavy nature of Pilgrims' Hall and its ponderous arch braces and desired a more elegant structure in a hall designed for regal display. Alternatively, perhaps it was simply a matter of timber supply. While relatively slender compared to the timbers in the rest of the roof, the curved struts are still huge timbers. Locating twenty-six of such heavy timbers for the lower curved struts, all of a similar curvature,

[68] Waddell, 58.

cannot have been easy. Diameters of logs would have to have been around 24 inches (610mm) to obtain two timbers; 18 inches (460mm) to obtain one timber, with a length of around 13ft (3.96m). Straight timbers of such diameters, obtained from a trunk, would have been relatively easy to locate; but curved timbers, often obtained from main branches, would be more problematic. One of the reasons why, in each frame, Herland adjusted the height of the tenoned spurs on hammer post and wall post may have been to accommodate the variable length and sectional dimensions of available timbers.[69] To reiterate, however, the nature of the framing of the curved struts, especially the lower timbers, indicates that Herland intended an important structural role for these seemingly exiguous components, a role analogous to arch braces in orthodox carpentry.

THE STRUCTURAL ROLE OF THE CORBELS

Recent scholarship has emphasised the role of the corbels as significant load-bearing elements in the structure of the Westminster roof.[70] But what was Herland's conception of the role of these masonry components?

In typical arch-braced and hammer-beam roofs, the late medieval carpenter understood the corbel as a component which received little, if any, vertical weight. Waddell provides the example of the sixteenth-century roof at Kings College Chapel, Cambridge, and its significant, intended, gap between wall post and masonry support, but fifteenth-century examples abound of hammer-beam and arch-braced roofs which dispense with corbels completely (Fig. 6.34).[71] Further, medieval building accounts refer to wall posts in the following terms: 'postes pendauntz', 'pendauntys', 'pendauntes', and perhaps more explicitly as 'pendant postes', the latter appellation taken from the records of the construction of Westminster Hall. [72] Such a designation again denotes that

[69] See the comments of William Harvey, 220-1.
[70] Courtenay & Mark, 387-93; Toby-Morris *et al.*, *passim*
[71] Waddell, 49. Hammer-beam roofs sans corbels, Norfolk churches: Hockwold, Holme Hale, South Acre; Suffolk: Bacton, Bramford, Cotton, Fressingfield, Ipswich St Mary at Quay, Newbourn, Roughham, Wetherden, Worlingworth. This list is by no means comprehensive.
[72] Salzman, 212, 215, 218, 219.

carpenters did not think of wall posts as compression members, being pressed onto the corbels by the weight of roof the roof above. Rather, they thought of them as tensional members, suspended from the hammer beams and being thrust against the wall by lower arch brace. The medieval carpenter thought, therefore, that rather than carry vertical weight, which was taken by the wall plate, the function of the wall post was to control lateral forces.[73] Arch-braced to the principal, the wall post counteracted the roof's tendency to spread, by moving the lateral force to a lower, more secure, point on the wall. It appears, then, that Herland, were he alive today, would be astonished at the assertions of late twentieth-century scholars regarding the load bearing function of the corbels.

The above analysis is further sustained by this telling fact alluded to earlier: many roofs which have corbels reveal a gap between top of corbel and bottom of post.[74] This was a circumstance found even in Westminster Hall. When the architect Sydney Smirke inspected the hall in 1836 he inserted his hand into such gaps he found between the wall posts and the corbels, a procedure repeated by C. H. Smith fourteen years later with the same result – an inconvenient fact conspicuously ignored by Courtenay & Mark.[75] Smirke, further remarked that the corbels were embedded so shallowly into the masonry, '[no] further than was absolutely necessary to keep them in their place', that they would be incapable of carrying significant weight. The few corbels on which the weight of the great arched rib had rested were 'in every instance broken.' He concluded that the notion of the great rib as a primary structural component communicating loading to the corbels was 'erroneous.'

---

[73] F. E. Howard in 1917 stated: 'roof carpenters improved the construction by the clever use of wall posts, reducing the thrust considerably'; Howard, & F. H. Crossley, *English Church Woodwork: a Study in Craftsmanship During the Mediaeval Period* (London: Batsford, 1917), 19. The addendum might be that the thrust is reduced at wall plate level, and is brought to a lower, more secure point on the masonry.

[74] From personal observation when working as a carpenter.

[75] Sydney Smirke, 'Remarks on the Architectural History of Westminster Hall' (including 'Second Letter'), *Archaeologia* XXVI (1836), 417-18. For C. H. Smith see, Thomas Morris, 'Glances at the Structural Principle of the Roof of Westminster Hall …', *Royal Institute of British Architects Proceedings,* 1st series, Vol. 3 (1849-1850), 7 (203).

Smirke's analysis appears reasonable. To be effective as a short cantilever, a corbel requires a downward force from the masonry to be applied to its buried upper face in order to balance the external downward weight of the wall post - weight that is exerting a rotational force at a point where the soffit of the corbel meets the edge of the masonry. For clarity, imagine the corbel as a miniature playground see-saw and the face of the wall as the fulcrum; uncle is sitting at one end, nephew at the other. The weight of the uncle, the wall post, needs to be balanced by his nephew located in the masonry. The scant embedded section of the corbel means that the masonry nephew sits very near the fulcrum of the corbel 'see-saw', and thus, as any youngster discovers, he exerts little downward force. Frustration ensues.

As evidence that the corbels were intended as primarily decorative features, their shallow embedment is convincing. But Baines also discovered a substantial cavities in the masonry above most of the corbels (which would remove 'nephew') (Fig. 6.35). Used possibly as an aid during erection of the frames, and certainly to accommodate the rear wall-post 'spurs' (discussed later), this cavity is, perhaps, the final nail in the coffin for the structural utility of the corbels. If, then, the corbels were not designed to carry weight, it was up to Herland to design a roof-frame which would distribute it elsewhere.

In Herland's roof, however, conclusions can never be so easily drawn. Before we make the corbels completely redundant, details in the wall-post framing demand that caveats be introduced. Firstly we return to Herland's wall-post spurs and their almost horizontal shoulders.[76] Lynn Courtenay noted that the configuration at this point on the wall post was analogous to a *tas-de-charge*, the springing point of a rib in masonry

[76] Framing these joints in our reconstruction made us realise the utility this arrangement must have had during the early stages of erection. Erecting fully morticed, braced post and beam carpentry is always awkward. The brace has to be lodged in a mortice, usually of the vertical timber, for the horizontal timber then to be placed on top. Aligning multiple mortices is never an easy procedure, and requires many hands. Attempting this at Westminster, Herland was dealing with massive timbers, and a slip might prove fatal. In part to facilitate less arduous construction, Herland adapted the lower mortices of the core and the curved strut by leaving them open at their rear end. This refinement, allied with the level-shouldered spurs, makes the erection process easier. The post and beam can be assembled, then eased apart slightly for the upper tenons to be fitted to the soffit of the hammer beam. The lower, open-ended, mortices can then simply slide onto the tenons of the wall post, with little further exertion.

vaulting.[77] Thus, mimetic of a masonry rib, it seems reasonable to argue that initially diagonal loads imparted from the curved strut may be to some degree be pushing *down* on the wall posts via those almost level shoulders, these near vertical loads being received more efficiently by Herland's spurs. Hence, Herland intended the corbels, in turn, to bear some vertical load. The innovative and unique carpentry of Herland's lower hammer-beam bracket further supports that contention. Herland appears to have deliberately designed the lower section of the arched rib to act as a fulcrum to a hammer beam in 'equipoise', as suggested by Thomas Morris, Ellis and Baines.[78] Indeed, the rib is positioned at the midpoint between hammer post and principal rafter. Acting as a fulcrum, Herland's rationale for cogging and notching the laminates becomes clear. The tripartite framing is functioning as an, albeit slightly inclined, post.[79] As such, it would be assuming enormous loads, and communicating them, near vertically, towards the foot of the wall post and the corbels. Such a function also goes some way to assuaging doubt about the exiguity of the curved struts.

Rather than an error on Herland's part, designing the lower arched rib to act as a fulcrum was his unique expedient to deal with the immense forces communicated by the roof. It was also an expedient of some prescience. To ensure the structural security of their roofs, modern American carpenters are advised to distribute the loads of their hammer-beam roofs via just such a hammer beam in 'equipoise', balanced on a wall-post fulcrum between the forces transmitted by the principals, and those of the hammer post (Fig. 6.37).[80] And yet, it was a type of construction rooted in Herland's purview of orthodox carpentry, an adaption of a contignation he must have carpentered hundreds of times: a rafter foot, but of enormous scale.

A final caveat apropos the functionality of the corbels arises from a component Herland framed into the rear of many of the wall posts, also called a spur. By employing a dovetailed housing to connect the two timbers, a joint difficult and time-consuming to

[77] Courtenay & Mark, 392; Courtenay (1990), 99.
[78] See nt. 61.
[79] Morris (1849-1850), 4 (230). Baines calls the core at this point a 'wood column', *Report*, 32.
[80] Ed Levin, 'Hammer-beam Roofs I', *Timber Framing* 48, June 1998, pp. 15-16; Ed Levin, 'Hammer-beam Roofs II', *Timber Framing* 49, September 1998, pp. 10-11.

cut, Herland took great trouble over these, not insubstantial, rear projections (Fig. 6.36). Did Herland look at those puny corbels inserted by the masons John Swallow and Richard Washbourne and shake his head in disbelief?[81] Did he then order them to cut out cavities beyond those corbels to accept the spurs he then was compelled to fashion in order to compensate for their incompetence? Remembering, then, Smirke's consternation at the shallow embedment of the corbels, shifting the base of the wall post, by means of those spurs, to a point of more substantial masonry, would direct any structural forces to a more stable footing.[82] Thus, while acknowledging Courtenay and Mark *et al.* and their load-bearing corbel contentions, it is not so much the corbels, but the masonry in the corbel *area* which is receiving vertical loads.[83]

---

[81] *HKW*, 529.

[82] Courtenay (1990), 105. It should also be remembered that the upper courses of the masonry wall were new, and that the long curing time of lime-based mortars, of months, even years, meant that the upper portions of the walls would have poor resistance to any thrust in this massive roof.

[83] As a proviso to the caveat, the spurs may have been inserted to maintain the lower wall post position longitudinally, *viz*., to prevent the wall post swinging around the fulcrum of the hammer beam, especially during erection. Unfortunately, as ever with Herland's roof, nothing is exoteric. Trusses 2 and 10 have no cavities behind the wall post, and have short, stubby spurs on one wall post only. The absence on truss 2 can be explained: the width of Westminster Hall narrows from south to north by more than a foot (305mm). Widths: South: 68ft 6in (20.88m); midpoint: 68ft 3in (20.80m); north: 67ft 5in (20.55m), (measured with a Bosch GLM 80 laser rangefinder). The gap between wall post and wall increases from north to south corresponding with the increasing width of the hall. It appears, therefore, that Herland carpentered all the frames to the same size. Truss 2, at the narrower end of the hall, is oversize, and so Herland embedded the eastern post into the masonry. Consequently there was no need for cavities and substantial spurs. The lack of cavities and substantial spurs on truss 10, where the hall is approaching its widest point, is difficult to explain. The observation that Herland carpentered the frames all to the same width casts doubt on Lynn Courtenay's claim that the gaps between wall post and wall were Herland's prescient attempt to prevent rot by providing ventilation (Courtenay (1990), 103, 107). The most northerly frames, where the hall is at its narrowest, are either embedded or tight up against the wall – so Herland was evidently not concerned about rot here. Rather, the majority of these enormous frames are carpentered undersize for constructional reasons. It is easier to erect the frame, fill any gaps with timber packing (probably folding wedges), and cover them with moulding, than erect the frame, realise it is too big, utter copious profanities, dismantle it, hack out substantial portions of masonry, and re-erect. Mr Ed Crane, Head Carpenter and Partner at Timber Framing and Conservation, Leicestershire, commented 'On trusses of this size I would have been more than happy with a six inch gap at either end to play with', private conversation, 13/01/2013. On frames of this scale, and given the idiosyncrasies of the masonry, it would have been impractical and probably impossible for Herland to carpenter all the frames to be a sliding, snug fit.

HERLAND'S STRUCTURAL INTENT: CONCLUDING REMARKS

Various scholarly attempts were made in the latter decades of the twentieth century to understand the function of Herland's monumental roof. This chapter should not necessarily be seen as a rebuttal of those earlier works, but as a complement to them. Further, the carpentry is open to interpretation; certainties are elusive.[84] With those provisos in place, we may précis Herland's design intent behind the Westminster Hall hammer-beam based on details of the framing.

Hugh Herland designed the roof to perform largely as any fourteenth-century hammer-beam of his experience. While his roof may appear avant-garde and experimental, the structural rationale was rooted in fourteenth century carpentered orthodoxy: braced post and beam framing, triangulated rafter 'feet'. The lower hammer-beam bracket in such carpentry functioned to replace arcade posts and bring the weight and thrust of the roof to a lower, more stable point on the buttressed Westminster walls. Why experiment with an untried technique, a structural timber arch, in such an intimidating commission for the ultimate in demanding clients? Nevertheless, as Herland would have observed at Winchester, the hammer-beam's heavy, agrestic aesthetic was not suited to the refined setting of a royal hall. Thus, to attenuate such bulkiness, his genius was to include a great arched rib to sweep through the frame. And, as this was a structure of unprecedented scale, he designed in some 'belt and braces' structural function for the composite rib.[85] To the casual observer, the arched rib appears a continuous autonomous component of major structural significance. Herland, though, designed the rib not as a continuous rigid arch, but as a series of bracing components to the vertical and horizontal timbers, components which would continue to fulfil their function as the frame dried and settled. Bracing duties are divided between the cores of

[84] In 1988 Jaques Heyman commented, 'It would be impossible to describe the roof in sufficient detail for the truth of its behaviour to be established unequivocally…. All that is possible is for the engineer to obtain some idea of the primary forces in his structure, to obtain some general understanding of the general way in which it behaves. To do this he must make some assumptions, some approximations; he must cut corners', 'Letters', 322.

[85] Quoting Shakespeare (Macbeth), Baines concluded that 'the introduction of the great curved rib in the original design was doubtless designed to "make assurance doubly sure"', *Report*, 32.

the arched rib and the curved struts, both of which serve to transmit forces in the roof, conventionally, to the foot of the wall post. The outer laminates of the rib have some structural duty also as braces, but, especially in their upper sections, they are primarily a visual device, configured to make the rib to appear larger and more prominent, both for aesthetic purposes, and for purposes of deception.

Did Herland think his roof could work without the arched rib? Yes, but he would need to bulk-up the section of the arch braces as at Pilgrims' Hall. The masonry would resist the thrust.[86] And, as I have contended, the central section of the rib, from hammer beam to hammer post, could be excised without structural catastrophe. The aesthetic, however, would be ruined.

Did Herland think his roof could work without the hammer-beam framing, with the rib acting as some form of masonry-mimicking arch? No. Orthodox carpentry, the massiveness of scantling of the hammer-beam contignation, and the componential make-up of the rib, all indicate the hammer-beam framing was not all designed to be suspended from the rib or the principal rafters.

The reader will note, then, that I am suggesting that, contrary to the majority of recent academic opinion, Herland thought the great arched rib primarily a visual component, with the built-in insurance of some structural function.[87] Weighing in favour of that contention is its composition: its composite **ᴜ** section and added mouldings, and the dubious structural function of the laminates. Herland made the rib appear larger and hence more structurally important than it is – a construction which still dupes modern investigators.[88] Are there, however, any precedents for this architecturally dominant transverse rib. And indeed, are there any precedents for such deception, for persuading the observer to apprehend as a primary structural component what is the mainly decorative. Such sources are the subject of the following chapter.

---

[86] Baines, *Report*, 32.

[87] Waddell thought the arched rib's structural role was negligible, and its function almost entirely decorative, 59.

[88] Toby Morris *et al*. state that the rib is 'nearly two foot square in section', 338. In fact, before moulding, the rib is just a little over half that section. Combined, the three structural sections measure 24½ x 12in (622 x 305mm).

Chapter 7

ARCHITECTURAL CONTEXTS AND STIMULI FOR WESTMINSTER HALL

In this chapter I place the roof of Westminster Hall in the context of fourteenth-century architecture. I look at some major and minor architectural trends and identify formal motifs which the designer Hugh Herland may have drawn on to inform his masterpiece. If visual duplicity was part of the Westminster design concept, do earlier examples of this gleeful ethos also exist? That question is resolved by the analysis of an astonishing timber structure located in the south-east of England, Ightham Mote, with which Herland may well have been familiar.

TRANSVERSE MASONRY ARCHES

The idea to insert a series of transverse arch forms in order to visually dominate the internal space of a structure was not the product of Herland's individual genius. For a century, from the early fourteenth to the early fifteenth centuries, a minor vogue already existed for the inclusion of transverse masonry arches in a variety of structures.

Bristol Cathedral (St Augustine's) contains an early instance of this formal device (Fig. 7.1). There, in the south aisle of the choir (begun *c.* 1310), a succession of stone transverse arches leads the eye towards the stained glass of the east window and an altar below. The arches rise to a stone beams which in turn support a series of complex transverse vaults. In Cambridgeshire, the tiny fourteenth-century sacristy at Willingham Church contains a fine example of stone arches, if of differing structural intent (Fig. 7.2). Here, slender pierced arches, redolent of tracery, support a stone flagged roof. Notwithstanding the small scale of the structure, however, to contain the thrust of this heavy roof the mason pitched the roof at a steep angle, and he was profligate with his buttressing. Buttressing is likewise extravagant for the similarly refined, but larger example which covers the south transept of Minchinhampton Church in Gloucestershire (Fig. 7.3). All these structures discussed thus far, however, are of modest span.

The trend for transverse arches in large-scale structures appears to have begun in Britain around the middle of the fourteenth century. The hall of Conway Castle (roof *c.* 1346) was spanned by a series of such arches, only one of which remains today (Fig. 7.4). The voussoirs of the arches were topped by masonry which formed parapets, cambered to follow the plane of the roof. Constructed thus, the function of the Conway arches was probably for the support of the purlins of a timber roof. Of slightly earlier date (*c.* 1330), and of similar form, were the Great Hall of the former palace of the Archbishop of Canterbury at Mayfield in East Sussex (Fig. 7.5 & 7.6), and a slightly lesser structure 25 miles away, at Battel Hall, near Leeds Castle in Kent. Mayfield is of four bays with three stone arches; Battel was of two bays with one arch. The Guildhall, in the City of London (1411), appears to have been a splendid late example of the integration of transverse masonry arches into a major structure (Fig. 7.7).[1] Although the roof was destroyed in the Great Fire of 1666, Wenceslaus Hollar's drawing of the aftermath of the conflagration shows the Guildhall rising from the devastation with, in addition to the gables, three huge arcuate structures still intact (Fig. 7.7). Are they masonry arches or huge timber principal rafters, their arcuation a slip of Hollar's pen? Two factors weigh in favour of stone construction: they seem far too massive to be of timber; and, while the timbers of the surrounding buildings have been consumed, these have survived the fire.

The exact nature of the original timber roofs atop the masonry arches of the above structures is largely unknown, although holes in the gables at Mayfield perhaps again indicate a purlin roof here. With a spans of around 32 feet (9.75m), 38 feet

[1] Christopher Wilson convincingly argues that the roof of the Guildhall originally had stone arches, 'The Original Design of the City of London Guildhall', *Journal of British Archaeological Association*, 3rd Series, Vol. 129 (1976), 1-7.

(11.58m) and 48 feet (14.63m) respectively, Conway, Mayfield and especially the Guildhall are large structures, and the naïve may suspect that patrons resorted to the skills of the mason in order to span the uncommonly wide void. Carpenters, however, would have been more than equal to the challenge.[2] The halls could simply have been aisled. As we have seen throughout this thesis, however, fourteenth-century patrons were developing a taste for halls uncluttered by arcade posts, and an aisled structure of regressive aesthetic would not befit elevated clients. Nonetheless, such shifting predilections for wide-span, aisless buildings did not preclude the carpenter. At nearly 50ft (15.24m) the nave of York Minster was, before Westminster hall, the largest void spanned by an English medieval carpenter. Here, aesthetic demands were reconciled by a timber vault. At Penshurst Place in Kent (*c.* 1341), the wealthy merchant and financier Sir John Pultenay had his grand hall spanning 39ft (11.89m) completed with an arch-braced collar roof.

Further, having the mason build a series of masonry arches created pecuniary, constructional and structural problems precluded in carpentered work. The carpenter would have to build the centering before the mason could begin work; no such temporary structures are required for a timber roof. The mason's arch is much heavier than any equivalent timber structure and has no tensile strength, so as we have seen with even the minor structures at Willingham and Minchinhampton, substantial buttressing would be required to bolster the external walls.[3] Further, as these arches are not composed simply of voussoirs, longitudinal stability must also have been a problem for these masonry arches. As the carpenter climbed the scaffold to erect his roof he would

[2] See the discussion of the reconstruction of the octagon at Ely Cathedral in Chapter 1 of this thesis.

[3] J. E. Gordon, *Structures or, Why Things Don't Fall Down* (London: Penguin, 1978), 175-9. Giles Gilbert Scott, for his post-blitz restoration of London Guildhall in 1954, included stone arches, which he believed formed part of the original 1411 design. To prevent the arches from spreading he inserted structural steelwork, Wilson (1976), p. 7. See also, 'Proposed Reconstruction of the Guildhall roof, London; Architect: Sir Giles Gilbert Scott', *Institution of Civil Engineers Proceedings* (1954) pt. 1, March, pp. 201-217. Of fourteenth-century stone arches, the major Victorian architect George Edmund Street remarked, 'in those arches there could be nothing at all of the principle of the tie… the lateral thrust had to be otherwise provided against.' 'On English Woodwork in the Thirteenth and Fourteenth Centuries', *RIBA Transactions,* 1st series, Vol. 14 (1864/1865), 104.

have been confronted with the series of arches surmounted by parapets. This arrangement is a somewhat precarious as disclosed by the eighteenth-century illustrations of Mayfield Palace, where the parapets have crumbled, leaving mainly the voussoirs (Fig. 7.5). Significantly, the restored roof at Mayfield has its main square-set purlin arch-braced to wall posts set on these transverse walls (Fig. 7.6). It is likely, then, that the timber roof serves as a shore for these low walls rather than vice-versa.

All of these processes and structural challenges demand more time and expense to negotiate. Yet these structurally gratuitous masonry arches were persevered with. Why? The conclusion must be that, with alternatives available, such visually imperious crosswise arches were constructed for reasons of visual enrichment.[4]

A significant addendum here is that masons, in seeking to incorporate transverse arches, may simply have been seeking to emulate the already well-established, quotidian practice of the carpenter. In what was a revolution in roof carpentry, from the static acceptance of the purely functional to the dynamic pursuit of form, from around the final quarter of thirteenth century carpenters had been routinely incorporating arcuate transverse 'Gothic' forms into structures of varying status, from barns to seigneurial halls.[5] Before then, the builders and denizens of such buildings seemed insensible to any aesthetic qualities of carpentry, positive or negative. When in 1214 Abbot William had the 'rafters and beams' of the abbey church of St Albans boarded over so as 'not to offend the eyes of the beholders', his remodelling was not compelled by the mundane carpentry. Rather, it was the smoke-blackened condition of the timbers which prompted the modification.[6] The prosaically functional scissor-braced rafters of the un-vaulted nave of Ely Cathedral (1237-40d) were open to view until well into the nineteenth

---

[4] Continental examples of stone transverse arches are found in the dormitory of the Monastery of Santa Maria, Poblet, Catalonia, Spain (early thirteenth-century), and again in Catalonia, in a royal hall, Saló del Tinell, Royal Palace, Barcelona (1359-62).

[5] For a discussion of shifting aesthetic concerns in medieval carpentry see C. R. J. Currie's lecture, 'The Age of Carpentry: the New Art and Society in Plantagenet England' (1991), < http://www.cool.conservation-us.org/byauth/currie/medcarp.html > accessed 05/04/2014; and also Julian Munby, 'Manorial Building in Timber in Central and Southern England 1200-1550', in Meirion-Jones & Jones (eds.), *Manorial Domestic Buildings in England and Northern France* (London: Society of Antiquaries of London, 1993), 55-56.

[6] Salzman, 379.

century, much to the chagrin of nineteenth-century aesthetes: 'The visitor is disappointed at seeing nothing but a set of rafters, which at so great a height appear not more substantial than those of an ordinary parish church or dwelling house … Surely these solid walls and massive arcades were intended for a nobler purpose. Persons … admire this timber roof for its lightness and ingenious construction … but it is totally out of place here.'[7] Early thirteenth-century builders and worshipers seem, by contrast, to have been oblivious to the aesthetic potential of roof carpentry.

From around the final quarter of thirteenth century, however, this state of stagnant aesthetic poverty began to change, and change was radical and swift. The transformation was accomplished by the relatively simple expedient of introducing heavier and arcuate bracing timbers, which produced, on an architectural scale, the Gothic arch. To apprehend how this visual transformation was achieved, one only has to compare the carpentry at the Old Deanery in the Cathedral Close at Salisbury (1258-74) (Fig. 7.8), with that of the hall and solar at Fiddleford Manor, Dorset (1324–1333d) (Fig. 7.9).[8] In the Old Deanery, the roof timbers of the base-cruck hall are a medley of light scantling and straight timbers, unrelieved by mouldings. The rickety functionality communicates an indifference to display and ornament. Fiddleford is a mere 29 miles distant from Salisbury, but more importantly, the gulf of seven decades confirms the stylistic revolution that English carpentry underwent during that short interval.[9]

[7] Robert Garland, Thomas Moule & B. Winkles, *Cathedral Churches of England and Wales,* 2 Vols. (London: 1838), Vol. II, p. 55. Vol. II, plate 71 is an illustration of the roof before being boarded over in the late nineteenth century.

[8] For the Old Deanery: N. Drinkwater, 'The Old Deanery, Salisbury', *Antiquaries Journal* 44 (1964), pp. 41-59, also Pevsner & Bridget Cherry, *Wiltshire* (1975), 391. For Fiddleford, see RCHME *Dorset*, Vol. III (1970), 271–276.

[9] Further examples of the aesthetic revolution in carpentry at the end of the thirteenth century: When the original twelfth-century linear framing of Fyfield Hall in Essex (the oldest parts date to 1167-85d) received its fourteenth-century renovation, it was fitted with curved braces, presumably to produce more contemporary 'Gothic' forms. Similar processes may be observed by comparing building campaigns at the former refectory of Romsey Abbey, Hampshire, (early thirteenth century and *c*. 1342-47d); and Medbourne Manor House, Leicestershire, the campaigns of c. 1238d and, a mere fifty years later, 1288. For Fyfield and Romsey, see John Walker (ed.), *The English Medieval Roof: Crownpost to Kingpost* (Essex Historic Buildings Group, 2011), 15, 27. For Medbourne see Nick Hill, 'The Manor House, Medbourne: the development of Leicestershire's earliest manor house', *Leicestershire Archaeol. Hist. Soc. Trans.* 75 (2001), pp 36-61.

Transverse arches dominate the spaces, given form by the curvature of specially selected, now heavier timbers. Here was a structure designed not merely for keeping out the elements, but for display.

For the carpenter, the use of heavier, curved timbers was not without its practical and economic inconveniences. Rather than using more readily available, straight timbers which could be sourced and felled with relative ease, for a building of multiple bays a series of trees with a similar arc and size would have to be located. Conversion of short curved baulks to produce arches of the required dimension is more difficult and laborious than converting a straight baulk to straight timbers. The curved baulk would perhaps be halved to produce a book-matched pair, whereas straight trunks were simply scappled down to produce square, box-heart timbers.[10] More labour was also involved in the cutting of the joints. Not only the heavier scantling, but the more oblique angle at which the curved brace met its associated timbers meant that longer mortices and tenons had to be cut. And the simple technique that had been used for centuries, the simple notched lap joint (Fig. 7.10) was no longer feasible on these big timbers; nor, indeed, was it aesthetically desirable. The more sophisticated mortice and tenon began to be increasingly cut, and consequently construction became hidden and mysterious. The 'notched lap' was perhaps thought too exoteric. As mortice and tenon carpentry became more common, the result was an inevitable increase in erection time, and indeed awkwardness, as now heavy, morticed, timbers had to be aligned for the frame to slot together. The point to extract here is that carpenters were pursuing form, transverse arcuate form, heedless to increased labour and costs. A similar philosophy infused Hugh Herland's approach to the carpentry at Westminster.

[10] See Oliver Rackham, *Ancient Woodland: Its History, Vegetation and Uses in England* (Dalbeattie: Castlepoint, new edn., 2003), 145, 459-61, for medieval management and use of timber; for conversion see F. W. B. Charles, *The Conservation of Timber Buildings* (Shaftsbury: Donhead, 1995), 47-57.

THE AGE OF THE RIB

Undoubtedly, Herland's arched ribs at Westminster Hall share the repetition, the visual dominance and transverse nature of the above-discussed masonry arches, but they differ in a crucial aspect. This difference is denoted by the name most scholars have given to Herland's arcuate component: the arched *rib*. With their heavy moulding and relatively slender sections, Herland's ribs are more akin to those components normally associated with a vault. Further, if a minor vogue for the transverse masonry arch seasoned the architecture of the fourteenth century, than a major vogue for the rib was one of its pervasive flavours, and not only in masonry.

The case for the rib as a decorative motif in late medieval architecture needs hardly to be argued, and, as the Middle Ages progressed, the rib became an increasingly dominant visual device in the vocabulary of late-medieval builders.[11] One only has to compare English vaults of the late twelfth and the early thirteenth centuries with those of the fourteenth century: the east end of the choir and presbytery at Ely Cathedral (1234-52) with its west end (1322-35) (Fig. 7.11); Canterbury Cathedral, and the vault of the choir (1175-84) with the that of the nave (1378-1405); and the nave of Wells, *c.*1185-1213 with the nave at Exeter, 1328-1375 (Fig. 7.12). These structures may be separated by few yards or tens of miles, but more importantly they are divided by a stylistic chasm of some 140 years of transformed architectural tastes and building practice. During this period, ribs proliferated in number and location. With tiercerons and liernes any structural utility is vanquished in the service of ornament. As can clearly be seen in the space of a few feet at Ely, not only did ribs increase in number, but also in mass. Before, the vault in its entirety, the ribs and the webbing with its often polychromed designs, formed a cohesive visual whole. In the late thirteenth and fourteenth centuries, the rib came to dominate the panorama of a vaulted space.

In a minor development, ribs became skeletal, 'flying', components, detached even from their customary context in a vault. Skeleton ribs adorn mainly lesser

[11] John Harvey, *Gothic England: a Survey of National Culture 1300-1500* (London: Batsford, 2nd edn., 1948), 52.

structures: the ante-chapel to the Berkeley Chapel in Bristol Cathedral (early fourteenth-century; Fig. 7.13); the doorway through the pulpitum of Lincoln cathedral (1330-40), and likewise the pulpitum of Southwell Minster (1320-40).[12] A grander and loftier example of this technique is in the chancel of St Mary's, Warwick (comp. *c.* 1392; Fig. 7.13).[13]

Ornament is the sole function of such flying ribs. The flat roof of the tiny Bristol ante-chapel hardly needs sustenance from arched supports. The Warwick chancel has its full complement of conventional ribs: transverse, diagonal, ridge, all of which happily perform the structural duty of assisting the webbing in countless other vaults.[14] But the Warwick mason decided to embellish his vault and added these detached, flying components. These fourteenth-century flying ribs are, therefore, decorative, structurally superfluous components. Ostensibly performing structural duties, their design is imbued with deceit.

---

[12] For Bristol: Pevsner / Andrew Foyle*, Somerset: North and Bristol* (New Haven: Yale University Press, 2011), 246; John Rogan (ed.), *Bristol Cathedral: History & Architecture* (Stroud: Tempus 2000), 92, 101, where the ante-chapel is called 'the monastic sacristy.'

[13] Fourteenth-century continental examples of flying ribs can be found in the south porch of St Vitus Cathedral, Prague, and the Chapel of St Barbara, St Stephen's Cathedral, Vienna.

[14] Debate regarding the structural function of the rib must be acknowledged here. Some scholars believe that ribs, to a greater or lesser extent, are structural, possibly functioning to channel the forces of a roof on to specific points: Francis Bond, *Gothic Architecture in England* (London: Batsford, 1906), 8-11; John Fitchen, *The Construction of Gothic Cathedrals* (Chicago & London: University of Chicago Press, 1961), 88-9; James Acland, *Medieval Structure: The Gothic Vault* (Toronto: University of Toronto Press, 1977), 83; Alec Clifton-Taylor, *The Cathedrals of England* (London: Thames & Hudson, Revised Edn., 1986), 43; Ian Sutton, *Western Architecture* (London: Thames and Hudson, 1999), 74; David Blockley, *The New Dictionary of Civil Engineering* (London: Penguin, 2005), 388. Others, perhaps most notably Paul Frankl, believe the rib to be a primarily ornamental feature: Frankl, *Gothic Architecture*, revised Paul Crossley, (New Haven; London: Yale University Press, rev. ed. 2000), 47, and nts. 17a and 17b. Notable also are Crossley's comments on page 10: 'In later Gothic 'textural' architecture … ribs (which may never have had any real structural function) lose their structural appearance and emboss the surface of the vault, or hang from it.' The debate is summarised by Nicola Coldstream, *Medieval Architecture* (Oxford: OUP, 2002), 55-6, 58-60. My own view is that medieval builders, especially during construction, viewed the rib as a support for the webbing. See Bond, 296-7; Acland, 82-83; Fitchen, 87-88, 98.

ST GEORGE'S HALL

Carpenters, too, constructed ribs, both conventional and 'flying', although, due to the nature of their raw material, of differing structural conception. Indeed, the mason's flying rib may again be his attempt to emulate the carpenter's arch braces and their open spandrels. The tensile strength of timber and its lighter weight, however, allowed the carpenter to construct prodigious examples more easily than the mason. One such monumental structure was built at Windsor Castle for Edward III: the roof of the great hall, formerly St George's Hall (*c.* 1362).

The form of the roof is only known from an illustration engraved in 1672 by Hollar, and despite scholarly assertions regarding the nature of the carpentry, his engraving is difficult to read, its perspective of receding frames illusory and confusing (Fig. 7.14).[15] The roof appears to have been conceived as a succession of somewhat spindly arched ribs rising to collars. Of slight section, heavily moulded, and framed with open spandrels, these arches possess the character of flying ribs. The interstices between rib, collar, and upper timbers (the nature of which is impossible to discern from Hollar's engraving) are filled with tracery. The loftiest timbers of the roof are concealed. Courtenay claims that the upper roof 'was paneled [*sic*] like the surface of a vault', and that, 'We thus have here, shortly after the middle of the 14th century, an important hybrid between vault and open roof.'[16] Such panelling, however, may also be interpreted a simply 'boarding' to cover unsightly structural roof carpentry. This refinement was widespread in many higher status buildings during the later Middle Ages, resulting in the waggon roofs that one sees in the West Country of England, and in the European Low Countries (see Fig. 1.35). The exact nature of the boarding, however, is secondary to the fact of its existence. If main structural timbers are concealed behind the boarding, then

---

[15] The roof is briefly discussed in Lynn Courtenay, 'Westminster Hall and its Fourteenth-century Sources', *Journal of the Society of Architectural Historians*, Vol. 43, No. 4 (Dec. 1984), 308-9. 'A complex structure full of anomalies', is the assessment of Christopher Wilson, 'The Royal Lodgings of Edward III at Windsor Castle', in Keen & Scarff (eds.), *Windsor: Medieval Archaeology, Art and Architecture of the Thames Valley* (Leeds: British Archaeological Association: Maney, 2002), 36.

[16] Courtenay (1984), 309.

the visible lower timbers, while appearing to the viewer as structural, are chiefly ornamental.

The dubious structural feasibility of the roof as depicted by Hollar supports the above contention. The main ribs, which appear not to be framed to any wall posts, seem too slender to carry any significant roof weight and manage thrust in this un-tied roof. Indeed, how the roof of 32ft (9.75m) span is prevented from spreading by the carpentry is a mystery, and one assumes thrust is contained by the mass of the masonry walls. The ribs also seem too slight to carry their surmounting vertical, and apparently larger section, timbers. Courtenay calls those vertical timbers 'perpendicular tracery', but their large section implies a structural function.[17] Perhaps the tracery was designed as a system of hangers, by means of which the arch rib was suspended from the true structural timbers concealed by the boarding. If so, then the arch rib's function is purely ornamental. Such a conception and construction, as we shall see shortly, is not as absurd as it may appear. It may be that a non-structural approach was the only way an arch rib of such elegance could be incorporated in a clear-span timber structure. As such it displays, much to the horror of the Gothic Revivalist, the medieval builder's taste for visual deception, in the form of ornament masquerading as structure.[18]

Perhaps, however, one is straying into scrutinising for the purposes of structural interpretation an engraving which was not intended for such rigour. Conjecture must result. It was unlikely to be Hollar's intention to leave a precise architectural record; for instance, the span of the hall is exaggerated.[19] One must view the picture as it was intended: as a generalised view, a vista. Nevertheless, the engraving is still highly instructive as to the formal desires of patrons of the highest echelons. It reveals that, in the third quarter of the fourteenth century, a succession of transverse, pointed arched

[17] Courtenay (1984), 309.

[18] See Chapter 1 for my comments on critics, such as Pugin and Ruskin, of the Gothic Revival. On apparently structural components which in reality have no such function, Thomas Morris was stirred to remark: 'if, in fact, they perform no such duty, we are invited to contemplate an idle parade of false sagacity and a laborious fabrication that excites admiration only when it deceives. I accept no such solution.' *Brief Chapters on British Carpentry* (London: Simpkin, Marshall & Co., 1871), 50-52.

[19] Courtenay (1984), 309.

ribs was desirable as a dominant feature in secular buildings of the utmost prestige, to be incorporated irrespective of structural function.

It may be taken as read that the future King Richard II and future patron of Westminster Hall would be familiar with the roof at the royal residence at Windsor.[20] It is also highly likely that Hugh Herland knew the roof.[21] Although its erection was supervised by the carpenter William Wintringham (*fl.* 1361-1392), Harvey suggests that the roof was designed by the King's Carpenter, and Hugh's probable father, William Herland.[22] As the roof formed part of one of the most 'beautiful and sumptuous' royal commissions of the early of the mid-fourteenth century, the suggestion that William Herland, the ordainer 'of divers works of the King', was intimately involved is entirely reasonable.[23] Harvey also suggests that Hugh worked at Windsor during the early 1360s, and, circumstantially, there is no evidence of him working elsewhere between 1360 and 1364.[24] Hugh, then, may even have been personally involved with the construction of the singular roof at this formative stage in his career. What is certain is that as early as 1366 Hugh was granted a royal annuity of 10 marks for life and a small house near Westminster Palace. Clearly, for him to be awarded such benefits, much of Hugh's early professional life must have been spent in royal works. Involvement in the extensive and splendid works at Windsor would certainly merit such a reward. His familiarity with, if not expertise on, the extraordinary aesthetic of the roof of St George's Hall and its structurally dubious, if not spurious, arched ribs, is almost certain.

As may be expected of a craftsman with such grounding, Hugh Herland was himself adept at the construction of timber ribs. His vault for the chapel of Winchester College (1388-94) is the apotheosis of the technique (see Fig. 1.26). Half a mile away, in the hall of Winchester Castle, while his arch braces there conventionally stiffen the tie beams,

[20] Nigel Saul, *Richard II* (New Haven; London: Yale University Press, 1997), 468-74.
[21] Courtenay says 'intimately', (1984), 309.
[22] *EMA*, 142, 143, 337.
[23] The Windsor adjectives are taken from the contemporary *Polychronicon*, quoted in *HKW*, 877.
[24] *EMA*, 137-8.

they are needlessly elongated and slender, and more homologous to flying ribs (Fig. 6.2). Significantly, the spandrels of those Winchester ribs, filled with perpendicular tracery, are redolent of St George's Hall, and they anticipate Westminster. Was the Winchester Castle roof a rehearsal of form for Westminster? Form was clearly a major concern for Herland at Winchester. His exiguous ribs, creating, albeit set lower in the roof, a St George's–like recession of arcuated forms, lend lightness and elegance to what could easily have been a ponderous, run-of-the-mill tie-beam roof.

Herland probably also knew another high-status fourteenth-century roof, in this instance carpentered for the most lofty of ecclesiastical patrons. The hall now modestly designated the 'Guard Room' in Lambeth Palace, was once the great hall of the Archbishop of Canterbury's main London residence (Fig. 7.15 & 7.16). Oddly under researched, the timber roof therein is one of the finest examples of fourteenth-century display carpentry, and, as would befit the main residence of a patron of the highest rank, it features the most advanced of contemporary architectural motifs.[25] Hence, a series of transverse Gothic arch ribs dominates the vista. Of heavy section, and deep elaborate mouldings, these appear to sustain the roof. The eye, however, has been led astray, for only scrutiny of the disguised carpentry reveals the hall's true construction, that of a mundane, post-excluding base cruck.[26] Significantly, dating probably to the late fourteenth century, the roof may have been carpentered by Hugh Herland. It is certainly adorned with foil and dagger motifs similar to the King's Carpenter's work at Westminster Hall and the Abbots' Hall, and based on such ornamental detail, Harvey

[25] The roof is briefly discussed by Harvey, 'The Mediaeval Carpenter and his Work as an Architect', *RIBA Journal*, 45 (1937–8), 739-40; RCHM *London,* Vol. II, *West London* (1924-1930), 79, 86; Hewett, *EHC*, 155; and Courtenay (1984), 304-5.

[26] Reset by Edward Blore in the 1830s, much repaired and heavily moulded, the true nature of the framing at the Guard Room is difficult to decipher. On balance, I agree with Harvey (although, confusingly, he also writes of 'principals') and Courtenay that the framing is of base cruck construction. Hewett, however, thought the carpentry consisted of principals arch-braced to the collar, which would mean the lower part of the 'cruck', was a discrete wall post. On some of the frames the spur does appear to extend all the way to a wall post, the resemblance to a cruck being conveyed, perhaps, by a large infill piece in the spandrel between arch brace, wall post and principal. Only a thorough archaeological investigation will confirm the nature of construction.

and Courtenay thought Herland's authorship likely.[27] The tracery between cruck and arch brace is, indeed, very similar to that at Westminster Hall between lower curved strut and arch rib. The difference lies principally in a single foil: at Westminster a trefoil replaces Lambeth's quatrefoil (Fig. 7.17). Harvey also insightfully noted further, more formal, similarities to Westminster. He writes that at Lambeth 'the inner arch [brace] and outer curved strut [he means the cruck] follow almost the same lines as [at Westminster] the lower curved strut and the lower portion of the great arch rib … while the half span [at Lambeth] of 14ft is equal to [at Westminster] the distance from the wall surface to the point where the lower curved strut intersects the [soffit] of the hammer beam.' An intriguing possibility is, then, that Herland at Lambeth was exploring the arcs and tangents he would shortly attempt at Westminster. A structural detail may also indicate the roof to be by Herland's hand. A signature technique of Herland, wall-post spurs, was discussed extensively in Chapter 6, and here at in the Guard Room they also occur (Fig. 7.18). Although jutting from the lower portion of a cruck blade, these spurs have identical structural intent to those at Westminster: providing a secure base for enormous arch ribs, and allowing the apparently continuous transition of heavily incised mouldings between components. As at Westminster, then, while the rib appears to spring from corbel and rise continuously to apex, on inspection, its source is the spur. I have argued earlier in this thesis that Herland may have experimented with, and adapted, techniques used in structures he carpentered in the months immediately prior to Westminster Hall. The Guard Room may have been Herland's last formal and technical 'dress' rehearsal.

A pause is valuable here to review the direction of this discussion thus far. We have looked at minor and major trends which imbued fourteenth-century design ethos and building practice: vista dominating, repeated transverse arches and slender ribs, and the

[27] The date of the roof has not been determined with precision. For a late fourteenth-century date see Courtenay (1984), 304-5; Harvey (1938), 739-740, 743; *EMA*, 141. RCHME, p. 86, thought the roof belonged to the mid-fourteenth century, while Hewett, on the basis of mouldings, idiosyncratically dated it to the early fourteenth century, *EHC*, 155, 310-11. Only Hewett's ascription would exclude Herland as carpenter.

flying rib. We have seen that these elements were incorporated into fourteenth-century buildings despite being structurally suspect, inconvenient, or gratuitous. Structural chicanery is inherent in gratuitous members. We have seen, at Winchester and Lambeth, Herland experimenting with these forms and concepts. Ultimately, in the form of the great arched rib, such ideas were to imbue his design for Westminster Hall. I have earlier argued that Herland thought the arched rib at Westminster a primarily visual feature, and the foregoing goes some way to show that such a conception would accord with fourteenth-century building philosophy and practice. A final fourteenth-century structure, with which Herland may well have been acquainted, proves that the idea of the merely ornamental presented as the structurally vital is not so preposterous.

'An Idle Parade of False Sagacity'? Ightham Mote [28]

In the earlier discussion of fourteenth-century stone transverse arches and timber arched ribs, one important building was notable by its absence: Ightham Mote in Kent.[29] The hall therein (1330-42d) is vital to this discussion because it contains arcuation in both mediums (Fig. 7.19). Intriguingly, constructed some fifty years before Herland's Westminster roof, Ightham contains principles of structural intent, and indeed, structural duplicity, which would later find home in the grander structure at Westminster.

Isolde Inge, the putative owner of Ightham in the 1330s, evidently wanted the transverse two-centred arch to be the most visually dominant element of the internal space. A stone arch, reminiscent of Mayfield and Battel, dominates the hall, dividing it into two unequal bays. On the two gable walls, similar, but timber, arch ribs answer the masonry arch. These arches seemingly support collars, which in turn support a crown post and a common-rafter roof, with an upper collar and soulaces. The upper roof is

[28] The phrase is Thomas Morris's, 50-52

[29] A general introduction to the complex of buildings is the National Trust guidebook *Ightham Mote* (revised ed., 2009); also useful is the Channel 4 'Time Team' DVD: *Ightham Mote, The Ten Million Pound House* (National Trust / Channel 4, 2005), also available via a Youtube search, May, 2014.

conventional and need not detain us. The viewer conversant with Westminster Hall will probably be struck by the similarity of the timber arched ribs to those at Westminster, albeit on a much reduced scale. Moreover, it transpires that the Ightham carpenter inserted the timber ribs irrespective of any structural need.

For decades it was stated that the timber ribs were sustained by corbels fixed into the masonry walls.[30] My own examination of the framing in 2012, however, kindled scepticism as to the true nature of the wall-post framing and the role of the corbels. Firstly, the corbels are of wood. Now, while unusual, wooden corbels *per se* do not preclude any structural role: a number of East Anglian hammer-beams and arch-braced roofs have wooden corbels embedded into the masonry walls.[31] More suspiciously, however, it was not possible to see the timber corbels extending into the masonry, indeed, gaps appeared to exist between wall and corbel. I concluded that perhaps unseen tenons formed the link. While researching his exhaustive *Greater Medieval Houses of England and Wales,* Anthony Emery had evidently observed the same thing. His judgement, however, was less circumspect than my own. He pronounced 'The corbels against the end walls are "flying corbels", supporting nothing.'[32]

In 2001, the framing of the hall underwent archaeological investigation; perhaps this had determined the structural role of the corbels. The findings of the survey were discussed at the Ightham Mote Building Archaeology Symposium on 19 October, 2001, and the minutes of that meeting are most elucidatory:

> Roof: Peter Leach [Consultant Archaeologist] also circulated a drawing of the roof structure, which he has had to completely reassess. It was previously assumed to stand on the corbels, but in fact they are not corbels at all. The structure hangs from the collars and wall plates: the

[30] A. J. Kempe, 'The Mote at Ightham, Kent', *The Gentleman's Magazine*, Vol. 7 (1837), p. 155. Henry Taylor, 'Ightham Mote', *Archaeologia Cantiana*, 27 (1905), p. 9; Margaret Wood, *The English Medieval House* (London: Bracken Books, 1983), 309; P. S. Barnwell & A. T. Adams, *The House Within, Interpreting Medieval Houses in Kent* (London: RCHME / HMSO, 1994), 43.

[31] For example the fifteenth-century church roofs at Carbrooke, Norfolk, and Tuddenham St Mary, Suffolk, among others.

[32] Anthony Emery, *Greater Medieval Houses of England and Wales, 1300-1500* (Cambridge: CUP, 1996), Vol. III, 358.

> corbels are not built into the walls (there is a gap between them) but form part of extended ashlars [wall posts]. The ashlars have tenuous support.
>
> RM [identity unknown] questioned how the forces worked: Stuart Page [Consultant Architect] observed that the whole thing is like a suspended net.[33] (Fig. 7.20)

The arched ribs in the hall of Ightham Mote are, then, a structural fallacy. I had noted during my own examination of the roof that the lower collars, although apparently arch-braced by the ribs, seemed of unusually heavy section to be serving merely as rafter struts, a suspicion further abetted by their cambered form. In the light of Peter Leach's comments, such anomalies may now be explained. A heavy section was necessary because the collars are crucial structural timbers: the arch ribs are dangling from the collars, in a manner reminiscent of a coat-hanger. Their attachment to the wall post is minimal, sufficient only to the purpose of preserving their crosswise placement. The wooden 'corbels' are not embedded into the walls but are themselves suspended from the wall posts. The carved corbel grotesques, supposedly carrying the load of the roof upon their shoulders, are a carpenter's joke. The heavy collar, then, is key to the roof's performance. Framed low in the roof, the 'collar' is acting in the manner of a tie, and thrust is to some extent is controlled by that tie - not by any arch ribs framed to wall posts. The carpenter also took the trouble to frame-in a substantial common-rafter foot, ensuring that it projected beyond the internal wall surface, a useful expedient for a roof in which he designed redundant arch braces. To précis therefore: the arched ribs at Ightham are not primarily decorative in conception with a modicum of structural function - they are entirely decorative with no structural function.[34]

Here, in the light of my comments in Chapter 6, the astute reader may already be anticipating an analogy with Herland's arched ribs at Westminster Hall. But before

---

[33] I am indebted to Mr Stuart Page, Consulting Architect to Ightham Mote, for sending me a copy of this unpublished report.

[34] While the central stone arch is obviously not suspended from the timber roof, its function must also be entirely ornamental. As the roof is an independent, self-sustaining structure, it requires no support from any lower arcuation.

completing that analogy, another startling detail regarding the composition of these arched ribs must be adduced. On my own inspection of the hall I had noticed that the arched ribs had a series of pegs inserted longitudinally. The ribs were clearly not pegged to the gable wall (besides being a bizarre technique, there is a gap between wall and rib). Such pegging could only indicate one thing: the ribs are not solid elements composed of one timber, but are laminates (Fig. 7.21). A consultation of Peter Leach's drawings confirmed that intuition (Fig. 7.22). In forming them, therefore, into what is analogous to two-thirds of Herland's Westminster **U** section, the Ightham carpenter made the lighter timbers appear larger in section than they are, and consequently duped the viewer into apprehending the ribs as performing structural duties, when they have none.

The analogy with Westminster Hall is now bellowing to be heard. In the hall roof of Ightham Mote, although to the observer key structural components, the carpenter inserted structurally functionless arched ribs into the roof, to the sole end of ornament. To facilitate the ruse, he laminated slender timbers to make them appear of greater section. Observers have subsequently been deceived for centuries. Consequently, my proposed ethos behind Herland's arched ribs, that of having a mainly ornamental function, has an, albeit extreme, antecedent.

Is it possible that the King's Carpenter could have been influenced by a curious structure in a house built for the middling classes?[35] Herland sojourned extensively in Kent, both on his own and the King's business. He kept a home, and possibly owned land, at Upchurch, twenty miles and a comfortable days ride north of Ightham.[36] He oversaw extensive royal works at the castles of Rochester, Queenborough and Leeds. Rochester is seventeen miles north-east of Ightham; Leeds twenty miles to the east. Perhaps more relevantly, the main road from London to Leeds would have led Herland just six miles north of Ightham.[37] Sadly, alas, this is the closest we can place Herland to

[35] Sarah Pearson describes Ightham Mote as being built by 'people of substance', *The Medieval Houses of Kent* (London: HMSO 1994), 32.
[36] *EMA*, 137.
[37] For medieval roads in Kent see Terence Lawson & David Killingray, (eds.) *An Historical Atlas of Kent* (Chichester: Phillimore, 2004), especially 51, but also, 35, 47, 61. A Roman road ran through Ightham; such

the Mote. Perhaps it was Richard II who demanded great arched ribs for his new hall. But again, while the King travelled extensively throughout Kent, six miles is again the closest we can place Richard to Ightham.[38] The possibility that Herland or his patron saw the roof at Ightham, while enticing, must remain, for now, unconfirmed. Nonetheless, what can be confirmed is that in mid fourteenth-century south-east England, the stamping-ground of Hugh Herland, carpenters were continuing the quest for form in their display roofs, regardless of structure, and with a spirit which was far from guileless.

To draw the threads of my argument together: in Chapter 6, I concluded that while the components of the Westminster arched rib had some structural function, Herland never intended them to function as a continuous arch. The function of that form was primarily one of ornament. To sustain that argument, in this chapter I have placed Herland's masterpiece in the context of major and minor trends in fourteenth-century architecture. It was a milieu in which craftsmen and patrons of the highest echelons were eager to incorporate transverse pointed arches, though suspect in both structural function and constructional convenience, in both secular and sacred spaces. Further, we have seen Herland experimenting with and accentuating Gothic transverse arches and ribs at Winchester and Lambeth immediately before carpentering the climax of that trend at Westminster Hall.

TREFOILS AND ANGEL HAMMER BEAMS

The other dominant motif of the middle ages, the trefoil, has not been mentioned. Hammer-beam framing intrinsically provides that form, and Herland, with his division of the Westminster roof into vertical thirds, and his long internal projection of the

---

roads were often still in use as major routes during the Middle Ages, Paul Hindle, *Medieval Roads and Tracks* (Botley, Oxford: Shire, 2011), 6, 9.

[38] See Richard's itinerary in Saul, 469-74.

hammer beams, emphasized that form. Extending beyond the hammer post and curved strut, the hammer-beam angels further heightened the cuspate nature of the trefoil. Masonry trefoils are usually found in minor constructions, doorways, window heads, tomb canopies and their ilk, the scant tensile capacity of masonry rendering more difficult their incorporation into larger structures. Exploiting the different structural properties of timber, Herland produced a trefoil on an architectural, colossal scale.[39] But, perhaps stimulated by forms he must have seen regularly in Westminster Abbey, Herland's genius was to also incorporate a two-centred Gothic rib, and consequently created architecture which integrated the two ascendant themes of late medieval art (Fig. 7.23). One may argue that Herland's design was almost passé; apart from the tracery, it paid no cognisance to current decorative trends for cinquefoils and four-centred arches, motifs determinative of what would be later dubbed 'Perpendicular'. Conversely the design may be interpreted as the culmination and celebration of over two centuries of aesthetic predilections.

Herland's roof was also the first to incorporate angel-hammer beams, and here too, we can find Herland's response to established fourteenth-century ornamental practice. From early in the century craftsmen had been adorning the cusps of various arcuate constructions with suspended figures. In Robert de Galmeton's bishop's throne at Exeter, the figures take the form of ministering angels (Fig. 7.24). Attached to the canopy cusps of the famous Percy Tomb in Beverley Minster, Yorkshire (*c.* 1328-39), are a variety of figures including angels, and similar figures can be found on other fourteenth-century tomb canopies (Fig. 7.25).[40] Herland himself was versed in the creation of these apparently floating, otherworldly figures: saintly forms terminate the pendants of his tester for Edward III's tomb (see Fig 1.24). Again, as with the trefoil,

[39] That the hammer beam is a tension component is the one fact virtually all scholars of Herland's roof agree on.

[40] Arthur Gardner, *English Medieval Sculpture* (Cambridge: CUP, new ed., 1951), 175-8. It perhaps should be noted that Lawrence Stone thought the 'tomb' to be an Easter sepulchre dating to *c.* 1340, *Sculpture in Britain: The Middle Ages* (Harmondsworth: Penguin, 2nd ed., 1972), 171.

Herland was to take such minor embellishment, transform it in scale and effect, and apply it to a grand architectural space.

By 1398, Herland's commission for Richard II at Westminster, with all of its innovative forms, was complete. In just a few decades, and after a century of dormancy, hammer-beam roofs, and angel-hammer beams, proliferated. In the final chapter I explore this proliferation, beginning with the contention that a constitutional upheaval precipitated this diffusion.

Chapter 8

POST-WESTMINSTER HALL DEVELOPMENTS: TYPOLOGY AND THE FUNCTION OF FORM

PROLOGUE: DEPOSITION

The paint can barely have been dry on Herland's angel-hammer beams when a pivotal political event was enacted below. It was no less than a revolution, and the irony of the first major occasion to unfold in Richard II's splendid new hall is patent. On 30 September 1399, announcement of Richard's deposition was read to a great assembly gathered beneath the angels. Alan of Walsingham reported that writs had been sent out 'to all those estates of the realm who were meant to attend parliaments, summoning them … they must be sure to attend.'[1] Similar writs were also issued for lesser clergy, chroniclers and scribes, presumably not only to document the revolution, but also to bring along any written evidence that could bolster the Duke of Lancaster's claim to the throne. 'The crowd of the people were so great', reported a contemporary chronicler, 'that it not only filled the hall itself, but also the adjacent courtyard … In the hall there was a splendid throne, beautifully decorated with a cloth of gold as befits a king.'[2] When the deposition had been approved by the assembly, 'to the great joy of all the people, who cried out loudly both inside the hall and outside, they sat [Lancaster] down on the aforesaid throne as king.'[3]

Proceedings were adjourned and the attendees recalled to an official Parliament to be begin a week later on 6 October. Parliament opened in Herland's hall, with the soon-to-be-crowned Henry IV presiding on the throne where lately Richard had sat.

[1] Christopher Given-Wilson, *Chronicles of the Revolution, 1397-1400* (Manchester: Manchester University Press, 1993), 124-5, 171-72.

[2] Given-Wilson, 165. The chronicler is anonymous, but Given-Wilson believes him to be a reasonably neutral eyewitness, possibly Thomas Chillenden, Prior of Canterbury, 162.

[3] Given-Wilson, 166.

This momentous Parliament of late autumn 1399 enjoyed one of the highest attendances of any medieval parliament.[4] From the wealthy lands of East Anglia, the Bishops of Ely and Norwich, the Abbott of Bury, and the Earl of Suffolk were in attendance, no doubt accompanied by retinues of officials.

As the lords and prelates returned home after the Richard II's deposition in the early winter of 1399 their minds must have been pondering the revolution they had just approved in Westminster Hall. It is not unreasonable to propose, however, that their minds had been stirred by things other than the deposition of a monarch. Modern visitors, inured to technological marvels, gaze awe-struck at Hugh Herland's improbable construction. In 1399, for many it would have been the first time they had seen the sensational new hall with its magnificent hammer-beam roof. In structure it was unique, perhaps incredible to the eyes of those gazing at the labyrinthine carpentry bridging the unprecedented void. In ornament and decoration it was equally unique, the first such roof with an array of recumbent angel-hammer beams miraculously bearing the impossible structure aloft. The hammer-beam roof had been around for a century, so ponderous and rustic, but here at Westminster Hall, Herland had unleashed its decorative potential. The prelates may have noted the rhythm of the trefoil frames created by the transverse framing, and how they functioned to focus the vision, to lead the eye towards the important part of an architectural space, creating here a tabernacle, a place for a deific king to preside. As they had processed through the hall, the angels had gazed down on them, as if lending divine approval to the ruthless mechanics of State. And yet this was a secular space. How much more effective such a structural and decorative program would be in a sacred space, a church: the vision of the contemplative, or the simply bored, to be channelled eastwards towards the mysteries of the mass enacted in the chancel; eastwards and heavenward towards the holy rood, and the

---

[4] Christopher Given-Wilson (ed.), *The Parliament Rolls of Medieval England 1275-1504*, Vol. 8: *Henry IV, 1399-1413* (Woodbridge: Boydell Press; London: National Archives, 2005), 3, 9; J. S. Roskell, *The House of Commons 1386-1421*, Vol. 1, *Introductory Survey, Appendices, Constituencies* (Stroud: Published for the History of Parliament Trust by Alan Sutton, 1992), 33; Nigel Saul, *Richard II* (New Haven; London: Yale University Press, 1997), 422.

Doom. Like salve applied by Christ to the eyes of the blind, Herland's roof suddenly revealed the potential of carpentry and carving for the intensification of liturgy and ritual.

Notwithstanding its undoubted splendour, as is the wont of medieval chroniclers regarding matters architectural, the unveiling of the miraculous structure sustained by angels passed without comment. On future patrons, however, Herland's roof was to have a profound impact.

EAST ANGLIA

It was the textile-rich parishes of East Anglia to which Herland's seeds were carried. By means of prosperous parishioners with one eye on piety, one on the truncation of purgatory, and perhaps both on inter-parish rivalry, here they bore glorious fruit. In this chapter, I argue that Herland's philosophy behind the construction of Westminster Hall drove this spread. To substantiate this contention, I identify examples of hammer-beam roofs carpentered in the region in the three decades following the completion of Westminster Hall. An analysis of these early roofs allows a typology to be created, and technical, formal and ornamental trends are thus determined. Discovered is a metier of carpentry with unexpected priorities regarding the reconciliation of form and ornament with structural stability.

Despite being a fount of medieval technology and art, some of the utmost quality, East Anglian hammer-beam roofs are oddly under-researched. The scholar is repeatedly limited to morsels of information scattered in gazetteers and church guidebooks, often of dubious academic rigour. Nevertheless, some sources possess more scholarly intent, in particular, the works of H. Munro Cautley and Birkin Haward. To continue this chapter, I now present a brief review of the writings of these two authors, prompted by the absence of like works, and, in one case, a serious flaw.

H. Munro Cautley (1875-1959)

'Outstanding … without any doubt, the greatest connoisseur of Suffolk, and indeed, of East Anglian churches' was Pevsner's assessment of the Suffolk architect and author of *Suffolk Churches and their Treasures,* published in five editions between 1937 and 1982, and the more limited *Norfolk Churches* (1949).[5] Cautley was steeped in church architecture. He designed three Ipswich churches, the fittings for many others, and he was Diocesan Surveyor from 1914-1947.[6] And his interest was not merely that of a disinterested technician: his father was rector at Westerfield Church, and for sixty years H. Munro read the lessons there. With timber roofs he was uniquely acquainted. He described how he had 'engaged in the repair of scores of such roofs and … examined them from scaffolds, bared, and even dismembered [them].'[7] Endowed with such intimate knowledge, Cautley's singular opinions on matters of ecclesiastical architecture and Suffolk hammer-beams are essential.

Cautley's writings on medieval timber roofs amount to a mere ten hagiographic pages in *Suffolk Churches,* and a further six in *Norfolk Churches*.[8] Yet their brevity is no reflection of consequence. A model of clarity, concision and passion, they are essential reading for any student of the subject, his comments elucidating structures and roof-types well beyond the borders of Suffolk and Norfolk. Indeed, putting aside some outmoded nomenclature – a result of the period in which they were written – any callow student embarking on a study of medieval carpentry would do well to postpone their reading of J. T. Smith and R. A. Cordingly, and turn to Cautley's ten pages in *Suffolk Churches*. Here one finds a potted typology of medieval timber roofs, from simple single-framed common-rafter roofs through to the most elaborate of double hammer-beams. Cautley's pithy 'Gazetteer', making up substantial sections of both books, is equally indispensable. Dating East-Anglian hammer-beams with any precision is often

[5] Pevsner, Enid Radclife, *Suffolk*, (London: Penguin, 2nd ed., 1974), 11, 62.

[6] Cautley's Ipswich churches are All Hallows, St Andrew, and St Augustine. A brief biography is contained in D. P. Mortlock, *The Guide to Suffolk Churches,* (Cambridge: Acorn Editions, 1992), Vol. 3, 243-4.

[7] *Suffolk Churches and their Treasures* (Woodbridge: The Boydell Press, 5th Edn., 1982), 88-89.

[8] *Suffolk Churches*, 87-97; *Norfolk Churches* (Ipswich, Norman Adlard & Co., 1949), 25-31.

uncertain, and dendrochronology in the region is piecemeal. Should the date of a roof be unclear or absent from a secondary source, or one suspects a Victorian roof masquerading as medieval, one should always consult the Gazetteer. A terse 'modern roofs' often settles the matter. Cautley, however, was no disinterested observer of these structures, and Pevsner's word is apt here: 'connoisseur.' Cautley enjoyed these roofs, and his enthusiasm and expertise leap from the pages.

Birkin Haward (1912-2002)

If comment on H. Munro Cautley is light on rigorous criticism and heavy on encomium, then the balance will be redressed as the work of Birkin Haward is considered. Haward was a prominent and successful Ipswich architect who, following his retirement in 1982, devoted much of his time to investigating the medieval Churches in his native Suffolk.[9] His interest was perhaps fostered by an early association with Cautley, to whom he was articled as a young man. Haward's research culminated in the publication of four books on a variety of topics related to Suffolk church architecture. Hammer-beam roofs are discussed in *Suffolk Medieval Church Roof Carvings* (1999), to a lesser extent in *Master Mason Hawes of Occold* (2000), and in Dymond & Martin's *An Historical Atlas of Suffolk* (1999).[10]

Haward's mission was to expand our understanding of the medieval craftsmen responsible for Suffolk ecclesiastical architecture. In *Mason Hawes,* he studied window tracery, and in particular arcade detailing, in an attempt to establish common authorship in a number of churches, and thereby trace the work of a Suffolk mason, Hawes of Occold. Haward readily admited the limitations and pitfalls in this comparative approach, but his justification of the method is valid: 'the dearth of medieval

[9] A short biography of Haward is inside the back cover of his *Suffolk Medieval Church Roof Carvings* (Ipswich: Suffolk Institute of Archaeology and History 1999)

[10] *Master Mason Hawes of Occold, Suffolk & John Hore, Master Carpenter of Diss: a Tribute to Two Fifteenth-century Master Craftsmen* (Ipswich: Suffolk Institute of History and Archaeology, 2000), *passim*; David Dymond & Edward Martin (eds.) *An Historical Atlas of Suffolk* (Ipswich: Suffolk county Council; Suffolk Institute of Archaeology and History, 3rd ed. revised, 1999), 170-2.

documentation leaves no other course open to those who would increase their knowledge of the craftsmen responsible for specific fine works of the period.'[11]

Unfortunately, however, conjecture, inconsistency and error plague Haward's writings.[12] Some of these flaws can be forgiven; conjecture may serve as a stimulus for further research in a field where the paucity of primary evidence is dispiriting. Haward's oeuvre, however, contains a study that has major flaws: his 'National Distribution of Medieval Hammerbeam Roofs' with accompanying map, in which he plots the location of all English medieval hammer-beam roofs. The 'National Distribution' is in both *Roof Carvings* and the more widely available edited work *An Historical Atlas of Suffolk*.[13]

Haward composed his map from information compiled from Mike Good's *Compendium of Pevsner's Buildings of England* (2005), a cd-rom containing a searchable database of terms and subjects found in the behemoth of English architectural history.[14] Entering the word 'hammerbeam', and limiting the search to a county volume such as 'Suffolk', returns a number of results from the fourteenth-century onwards. Some of these results are post-medieval, even Victorian, so the researcher has to be circumspect. For his home county of Suffolk, Haward concluded that there were fifty-five medieval single hammer-beam roofs.[15] My own list, drawn from a wider variety of sources, now stands at sixty-six. Further, Haward includes Suffolk hammer-beams which are clearly

[11] Haward, *Hawes*, 1,

[12] Haward discusses hammer-beams in *Mason Hawes* because he incidentally proposes a carpenter John Hore, as builder of the roofs completing Hawes's masonry, but as Haward himself admits, the association between Hawes and Hore is pure conjecture, 3. Sometimes, as with his comments on the work of the Rollesbury brothers at Bacton, Suffolk, a seed of documentation blossoms into an amaryllis of speculation, *Carvings*, 30; see also page 22 for more conjecture. Also on page three of *Master Hawes* we read that only six Suffolk medieval hammer-beams were constructed without collars; on page forty-four the number has reduced to three. My own research has revealed only two Suffolk hammer-beams of collarless construction: Wickham Skeith and Bardwell. Indeed, Haward would have benefited from a proof-reader. On the same page (p. 1) in his introduction to *Roof Carvings*, it is stated that that Suffolk has 58, and then 55, single hammer-beam roofs. By the National Distribution Map on page 170 the number has settled to 55.

[13] *Carvings*, 170-1; *Historical Atlas*, 170

[14] Haward, *Carvings*, 170.

[15] Haward, *Carvings*, 1, 170.

post-medieval, such as the churches at Hitcham and Hawstead. I have excluded these roofs, so the discrepancy is even greater.[16]

The totals, however, are not the principal problem. I am sure, indeed hope, that a future researcher will make discoveries which will require the amendment of my own gazetteer. More seriously, most flawed is Haward's plotting of the distribution of medieval hammer-beam roofs. Haward, rightly, comments at length on the remarkable fact that most hammer-beam roofs are in East Anglia, indeed mainly Norfolk and Suffolk, going on to eulogise the carpentry skills of his Suffolk forebears.[17] But Haward does his forebears a disservice, because the true picture is even more remarkable. For example, I was astonished to learn that two medieval hammer-beam roofs were local to me in Leicestershire churches, one just down the road at Blackfordby, another at Thurmaston. Having travelled hundreds of miles researching hammer-beams, this was a frustrating discovery - two were on the doorstep all the time. Both, however, prove to be Victorian rebuilds. The error is repeated, this time in the Shropshire. The age of hammer-beam carpentry in Shropshire was the late sixteenth and seventeenth centuries,[18] and although fifteen pre-nineteenth century hammer-beams adorn Shropshire churches, only two have credible medieval claims: Alberbury and Ford, and their dates are uncertain.[19] A further medieval possibility is a rare example in a hall: at Vaughan's Place in Shrewsbury.[20] Thus, at best, the county holds three medieval hammer-beam roofs. Haward's map plots five, and he excludes Alberbury. A final county example is

---

[16] Hitcham, with its Jacobean detailing, is clearly post-medieval, Cautley (1982), 296; Mortlock, Vol. 2, 119; bizarrely, Pevsner, *Suffolk* (1974) describes the roof as 'Dec'; *NHLE* does not date the roof but it says it contains 'monograms of James I and Charles I', an observation made also by Cautley. Hawstead is described by Cautley as 'C16', (1982), 293, by Pevsner as 'latest perp', with money still being bequested in 1552; by *NHLE*: 'probably not finished before 1550.'

[17] Haward, *Carvings*, 170.

[18] Eric Mercer, *English Architecture to 1900: the Shropshire Experience* (Almeley, Herefordshire: Logaston Press, 2003); 82-3, 279, 302-4

[19] My conclusions have been drawn from, D. H. S. Cranage, *An Architectural Account of the Churches of Shropshire* (Wellington: Hobson & Co., 1901, 1912); John Leonard, *Churches of Shropshire and their Treasures* (Almeley, Herefordshire: Logaston Press, 2004); Mercer; Pevsner / John Newman, *Shropshire* (London: Yale University Press, 2006); *NHLE*.

[20] The date of Vaughan's Place is uncertain; Pevsner: 'roof reconstructed accurately after a fire in 1917, must be C15', 537.

Hampshire. According to Haward, the county possesses two medieval hammer-beams, whereas, as elucidated in Chapter 4 of this thesis, it contains half that number.

Culpability for these errors is divided. Mike Good's database unaccountably lists the two Leicestershire hammer beams as 'C15' (albeit with a question-mark in his 'notes'), while the Pevsner's print volume is unequivocal in stating that they are Victorian. Three of Good's five 'perpendicular' Shropshire examples are considered by other sources, including the 2006 Pevsner volume, to be post-medieval.[21] Good's 'Compendium', then, might be useful as a starting point, but his entries need cross-referencing with other sources, which it seems Haward neglected to do. This is a crucial omission, for the distribution of medieval hammer-beams proves to be even more astonishing than Haward's map depicts. Medieval hammer-beam roofs are even more numerous in, and even more tightly indigenous to, East Anglia than Haward and previous scholars had believed.

Nonetheless, despite such reservations it must be added that Haward's work on hammer-beam roofs, especially in *Roof Carvings* does have merits. His comparative method is painstaking - dauntingly so – but it is a vital avenue of approach. Study of such detail in hammer-beam roofs may uncover developmental trends and signs of common authorship. Haward also provides useful models for the classification of hammer-beams, particularly with regard to their ornament. The terms and their abbreviations: 'Hammerbeam Angel' ('HbA'), for the applied carved figures, and 'Angel Hammerbeams' ('AHb'), for the carved constructional timbers, are apposite and, with minor modifications, I have adopted them.[22] The gazetteers are useful, containing description, often dimensions, and invaluable photographs. Indeed, the photographic record of the woodcarver's art in *Roof Carvings* is a labour of love and constitutes a priceless archive. Moreover, Haward was first serious modern researcher to take a forensic interest in what has been a scandalously neglected field: the treasures of the East Anglian hammer-beam roofs. With the flaws acknowledged, as a pictorial reference and

[21] Churches at Ashford Carbonell, Astley Abbots, Smethcott. Mercer thought most of the Shropshire hammer-beams referred to by Good as 'perp' were post-reformation, 302-4.

[22] Haward, *Carvings*, 23

as stimuli for further research, his wonderfully illustrated volumes remain works of crucial importance.

FIFTEENTH-CENTURY HAMMER-BEAM ROOFS: DATING PROBLEMS:

To gain any useful insight into the stated aim of this chapter, the development of early fifteenth-century hammer-beam roofs, clearly some attempt must be made at ascribing dates. Here, I briefly discuss the problems and pitfalls intrinsic to the process.

Primary documents and dendrochronology are the only reliable methods of dating medieval timber structures. The former are extremely rare, and, with regard to East Anglia, much work needs to be done regarding the latter. At the time of writing, of this unique reservoir of medieval art, only three hammer-beam roofs had been tree-ring dated. Cost is clearly a major factor, but such a state of affairs perhaps also connotes academic indifference. In the face of this dearth of evidence, secondary sources such as English Heritage's *National Heritage List for England* and the Pevsner volumes often forego completely any attempt at precise dating, and merely list the structures as 'C15', or even more vaguely, 'Perp'. The following case study illustrates the difficulties involved in dating medieval hammer-beam roofs.

All Saints Church in the fenland village of Tilney All Saints is a rarity: a well-documented medieval church. A very limited number of pre-reformation English churchwardens' accounts survive; for example, of around 450 medieval churches in Suffolk, a dozen such records remain.[23] Tilney possesses a Norfolk example, and it is one of the most complete of the medieval survivors.[24] Covering the years 1443 to 1589, the accounts are a record of the minutiae of quotidian expenses: wax for candles; nails, hinges 'lockys, hespys and stapullys'; payment to labourers for digging ditches and laying hedges; 'a nette to close owles owte of the chyrche.'[25] Surely here the researcher would

[23] Judith Middleton Stewart, 'Parish Activity in late Medieval Fenland', in Burgess & Duffy (eds.) (2006), 283.
[24] A. D. Stallard, *The Transcript of the Churchwardens' Accounts of the Parish of Tilney All Saints, Norfolk: 1443 to 1589*, (London: Mitchell Hughes and Clarke, 1922).
[25] Stallard, 106, 122.

find evidence of a major building project completed during the period of accounts: the construction of a splendid double hammer-beam angel roof (Fig. 8.1). But it is the daily detail wherein lies the problem. For a major project such as a new roof, a formal written contract would have been drawn up with the craftsmen, and thus no need to enter the works into the churchwardens' record of daily expenses.[26] Medieval building contracts fall into the 'hens' teeth' variety of documentary evidence, and no such contract has been found for Tilney. Sporadic evidence of building works exists in the Tilney accounts, but it does little to advance the dating process. Minor and moderate expenses and bequests are recorded throughout the 145-year period, and the student is left to infer when the roof was constructed by searching for an upsurge in these events. After studying the accounts, my own tentative conclusion was that the roof was constructed in the final third of the fifteenth century.[27] Nonetheless, this approach is full of uncertainty, and it is one that the authority on the accounts, Ms Middleton-Stewart, largely eschews.

The primary purpose of Middleton-Stewart's paper was not to date Tilney's double hammer-beam, but she surmises that it was completed, on the evidence of the 'Tudor' roses found in the roof, to sometime after 1485.[28] As the rose, the most perfect of flowers, was an emblem of the Virgin Mary found in countless churches of the later Middle Ages, 'Tudor' roses must be identified with caution.[29] A white on red colour is the surest indication of a Tudor rose, and Tilney has lost most of its paint. The secondary sources, Cautley and Mortlock, make no attempt to date the Tilney roof. For English Heritage, without amplification it is 'late C15'.[30] The most curious ascription is in Pevsner which baldly states: 'Perp clerestory. Dec the hammer-beam roof.'[31] Palpitations in the heart of the hammer-beam scholar are, however, fleeting. A pre-1350 double hammer-beam roof, presumably dismantled and reset on the fifteenth-century clerestory? Surely a misprint, although, interestingly, the bay divisions of the roof do

[26] Middleton-Stewart, 291, 292.

[27] Stallard, 73-98; Middleton-Stewart, 294.

[28]Middleton-Stewart, 290, 291.

[29] Heather Child & Dorothy Colles, *Christian Symbols, Ancient and Modern*, (London: Bell, 1971 1971), 243. Celia Fisher, *The Medieval Flower Book* (London: The British Library, 2007), 106-7.

[30] *NHLE*, < http://list.english-heritage.org.uk/resultsingle.aspx?uid=1264202 > accessed 31/09/2014.

[31] Pevsner, Bill Wilson, *Norfolk 2* (New Haven & London: Yale University press, 2002), 732.

not match their counterparts in the clerestory masonry. Does this inconsistency prove different design dates? Possibly; but just as likely is that the discrepancy is due to the exigencies of the carpentry: keeping the lengths of bay and intermediate bay consistent while assuring an adequately short purlin length to enable the purlin to fulfil its function of supporting common rafters. Perhaps the mason did not realise this, and a lack of communication with the carpenter compounded the problem. But note how, in striving for an accurate date, I am plummeting into unacceptable levels of speculation.

Bequests occur in the Tilney accounts so their general merits as a dating tool ought to be evaluated. Wills constitute a vital, if again scarce, resource for the dating of structures, as pious lay folk made their death-bed donations towards the upkeep of the church fabric. Once discovered, authors of secondary works clutch these bequests with the joy of a shipwrecked sailor clinging to a raft. To mix metaphors, however, a wet blanket of caution must be applied to their unqualified use. Structural and further documentary evidence often highlight a significant gap between the testator's wishes and completion of works. Thus, at Bressingham Church in Suffolk, a bequest for the building of the clerestory was made in 1499; while a stone panel dated 1527 between two of the north clerestory windows indicates that the work was not completed until nearly thirty years later.[32] At Rougham, in the same county, William Leyer died in 1444 and left 20 marks towards rebuilding the tower; only when wife Margery died in 1460 did the monies become payable.[33] In 1497, William Cady of Rushmere in Suffolk left funds to pay for the building of a new steeple; twenty years later the work had still not begun.[34] Thus, in the absence of corroborative evidence, it is unwise to use wills alone to fix a precise construction date.

---

[32] John Blatchly; Peter Northeast, *Decoding Flint Flushwork on Suffolk and Norfolk Churches* (Ipswich: Suffolk Institute of Archaeology and History, 2005), 108.
[33] Blatchly & Northeast, 67.
[34] Peter Northeast, 'Suffolk Churches in the Later Middle Ages', in Harper-Bill (ed.) *East Anglia's History* (Woodbridge: Boydell / The Centre of East Anglian Studies, University of East Anglia, 2002), 95.

EARLY FIFTEENTH-CENTURY HAMMER-BEAM ROOFS

Evident, then, are the difficulties of dating medieval church construction for the researcher intent on determining the development of post-Westminster Hall hammer-beam roofs. Clearly, though, in order to gauge any influence of Herland's great roof, early fifteenth-century examples must be isolated. Nevertheless, some progress can be made.

Below, listed in chronological order, is a table of roofs with hammer beams constructed in the first three decades of the fifteenth century. The dates have been determined from the study of meagre primary sources, and a comparison and synthesis of secondary sources – from the eighteenth-century topographer and historian Francis Blomefield, to the twentieth-century and Pevsner, Cautley and Mortlock. To further aid the dating process, I have personally visited all the churches and examined the roof carpentry and carving.[35] Details in the carpentry, ornament and the associated masonry all provide clues as to construction date. Carved ornament is integral to these structures, many of the roofs serving as vehicles for such ornament. In the spirit of Birkin Haward, therefore, I have also studied the carving in an attempt to establish possible links with carving of a similar style and execution, but of known date.

[35] See Appendix 1.

Table 8.1: Early Fifteenth-Century Hammer-beam Roofs.

BUILDING	CONSTRUCTION	SPAN	PITCH	DATE	CERTAINTY	EVIDENCE	COMMENTS
DEBENHAM, Suff.,	TB/HB	22ft 6in / 6.86m	shallow	1403 ± 6	***	tree-ring	no collar
St Mary Magdalene	no collar						HBAs (lost)
NORWICH, Norf.	HB/AB	19ft / 5.79m	shallow	early C15	**	Structure	atypical form
St Giles	no collar					Doc 1 / Doc 2	RFHBs
KINGS LYNN, Norf.,	TB/HB	32 ft / 9.75m	shallow	*c*. 1400-19	***	Doc 1 / Doc 2	RFHBs
St Nicholas							
GREAT SHELFORD, Cambs,	TB/AB/HB	23ft 8in / 7.21m	V. shallow	1400-11	**	Structure	atypical construction
St Mary						Doc 2	RFHBs
WESTERFIELD, Suff.,	HB/AB	19ft / 5.79m	steep	early C15	*	Structure	no aisles / clerestory
St Mary Magdelene	collar / KP					Doc 2	HBAs; CFs
BEESTON-next-MILEHAM, Norf.	HB/HB	22ft 11in / 7m	shallow	*c*. 1410	**	Doc 1	refined carving, defaced
St Mary	no collar						RFHBs; WPFs
WINGFIELD, Suff.,	CR/HB	19ft / 5.8m	shallow	*c*. 1415	**	Doc 1 / Doc 2	No purlins
St Andrew	collar, soulaces					structure	RFHBs
BILDESTON, Suff.,	TB / HB	21ft 7in / 6.57m	steep	*c*. 1420	**	Structure	no collars
St Mary	no collar					Doc 2	HBAs (lost)
BARDWELL, Suff.,	HB/HB	26ft 6in / 8.08m	steep	*c*. 1421	**	Doc 1	restored paintwork
St Peter & St Paul	no collar						HBAs (most lost)
WIGGENHALL, Norf.,	TB/HB	21ft 6in / 6.55m	shallow	1419 ± 16	***	tree-ring	PFHBs
St Mary Magdalen	no collar					(aisle roofs)	
ELY CATHEDRAL	HB/HB	*c*. 33ft / 10.06m	shallow	1426 – 27	***	tree-ring	restored paintwork
N. & S. transepts	no collar						RFHBs; CFs
MILDENHALL, Suff.,	TB/HB	22ft 6in / 6.86m	V. shallow	1420-30	**	Doc 2	refined carving
St Mary							RFHBs; WPFs
GREAT CRESSINGHAM, Norf.,	HB	17ft 4in / 5.28 m	shallow	*c*. 1430.	**	Structure	refined upper framing
St Michael	no collar					Doc 1 / Doc 2	RFHBs; CFs
BURY ST EDMUNDS, Suff.,	HB/AB	26ft 9in / 8.15m	shallow	*c*. 1430	**	Doc 1 / Doc 2	refined carving
St Mary	collar						RFHBs; WPFs

KEY:

CONSTRUCTION: principal transverse frames are given first, then intermediates. Abbreviations: TB: tie-beam; HB: hammer-beam; AB: arch brace; KP: king post; CR: single-framed common rafter roof. For example, HB/AB is of hammer beam construction in the principal frames, and arch-braced in the intermediates.

COLOUR-CODING: Brown: tie-beam/hammer-beam roof; Purple: hammer-beam roof *sans* collars; Green: hammer-beam roof with collars; **Black**: atypical construction.

PITCH: steep: above 45°; shallow: below 45°; v. shallow: c. 24° or below. 'Shallow' does not mean these are low-pitched roofs which many commentators claim as typical of the late medieval period. Most appear to have a pitch of around 40°.

CERTAINTY: Degree of certainty of date, thus, * : possible; ** : probable; *** : certain.

EVIDENCE: Evidence for date. 'Structure': construction or style connotes early date. 'Doc 1': primary documentary sources; 'Doc 2': secondary documentary sources where consensus exists.

COMMENTS: RFHB: angel hammer beams, the main timber is carved into the form of a recumbent angel or figure. HBA: discrete, applied figures, morticed onto the ends of hammer beams. WPFs: Wall post figures. CFs: Corbel figures.

The rationale behind the dating of the structures in Table 8.1 is given in Appendix 3. The majority of dates in the table are not precise to within a year or two (Ely is the only exception). Most structures are dated within parameters of ten to fifteen years or so. The order, therefore, in which I have placed the roofs is not meant to be definitive as to chronological sequence of construction. The first five in the table especially could be interchangeable. The reader will also note that the construction dates have varying degrees of certainty. The buildings marked 'certain' need least discussion with regard to their dating. These roofs are vital because they serve as reference structures against which other possible early roofs may be compared. Moreover, it is not only the carpentry which is vital for providing datal clues for other structures. Particulars of these 'certain' roofs, for example, window tracery, corbel figures, and flushwork are equally valuable. If similar detailing is found in other early candidates, it may indicate coevality. Regarding the more problematic 'probable' category, no one piece of evidence is conclusive as to date. Individual pieces of evidence are assembled into a buttress of proof of uncertain resistance. Regarding the 'possible' category, other contenders exist, but I have included just one roof: Westerfield Church, Suffolk. The evidence is tenuous and open to interpretation, but Westerfield's tentative structure renders it worthy of inclusion.

Table 8.1 permits the creation of a typology, a typology which elucidates the structural and aesthetic development of these roof-frames immediately post-Westminster Hall. The first thing to note is that two basic types are observed: Type 1: tie-beam roofs with inserted hammer beams (TB/HB); Type 2: structural hammer-beam roofs. Type 1 roofs in putative date order are: Kings Lynn, Debenham, Great Shelford, Wiggenhall, Bildeston and Mildenhall.[36] These roofs belong in a distinct structural category because, unlike structural hammer-beam roofs, they rely on the time-proven tie beam for their stability. Hammer beams are found in the intermediate frames and their function is decorative. This group may be further refined by their use or otherwise of queen struts

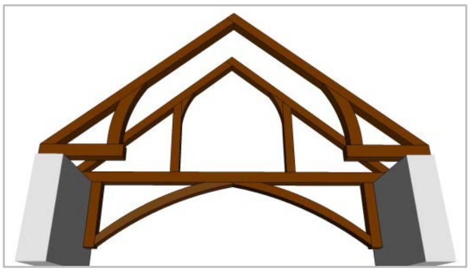
[36] The dating parameters of the first three roofs are very similar, and their order could be rearranged.

and recumbent angel-hammer beams (Table 8.2). I will then go on to discuss the various types and sub-types in detail.

Table 8.2: Early Type 1, Tie Beam / Hammer-beam Roofs

Type 1.1: RAHBS / QUEEN STRUTS	Type 1.2: NO RAHBS / QUEEN STRUTS	Type 1.3: HYBRID
King's Lynn Mildenhall Wiggenhall	Debenham Bildeston	Great Shelford

TYPE 1.1: THE 'LYNN' TYPE.



King's Lynn and Mildenhall are early examples of a distinct group of roofs located mainly in north-west Suffolk, south-west Norfolk and east Cambridgeshire (Fig. 8.2). The roofs are relatively low-pitched; the hammer beams are usually of the 'panel' type (discussed below) and are un-braced; ornament is extensive. Between Lynn and Mildenhall, a line of later Type 1.1 church roofs follow the western shoulder of the Brecks along the route of the present-day B1112.[37] King's Lynn St Nicholas is probably the earliest example, and located in such a prominent town – a port of perambulating travellers to boot – it must surely have been the structural and aesthetic benchmark for this group of roofs. Thus, Lynn established a style which then flowed, albeit limited in number, southwards along

[37] Proceeding south from Lynn, these are: Methwold, (described by secondary sources as 'C15'), Hockwold ('late Perp'… early C16') (Pevs), Lakenheath ('C15' but by Mortlock as 'early C15', probably on account of the strong affinity of its carving with that of Mildenhall).

the shoulder of the Brecks to Mildenhall, and south-westwards into the fens to prosaic Wiggenhall.[38] As Lynn is the prototype, I will consider its structure specifically.[39]

The Lynn roof is a structure of opulent sophistication, carpentered by a craftsman with a strong sense of proportion. The frames are divided transversely into visual units of one-sixth. Perhaps responding to structural demands in this shallow-pitched roof in an unusually wide nave (32ft / 9.75m), the carpenter chose to frame queen struts into his tie-beams. These each meet the principal rising from points at approximately one-third of the span. The hammer beams terminate at one-sixth span. These transverse, one-sixth, units may be arranged thus: 1:1:2:1:1. Moreover, further details confirm that the carpenter intended the queen struts' function to be not merely structural. Formal concerns were evidently in mind since he chose to arch-brace the internal faces of the queen struts to the rafter, a structurally excessive, but visually dynamic move. Contrast these refined queen struts with the coeval roof at Debenham and its austere framing (Fig. 8.7). At Lynn, any similar monotony is obviated by the rhythm of receding gothic arches achieved by the arch-bracing of the queen struts. The carpenter's quest for form and ornament is further evident in the secondary vertical struts adjacent to the queen struts. These perhaps add stiffness to the frame, but again their function is mainly visual, that of providing frames for tracery.

In an astonishing example of ornamental prodigality, the spandrels of those queen-post braces have been carved (Fig. 8.3). The subject matter appears to be a variety of animal and foliate designs. Virtuose is their realization, yet these figures are placed so high in the roof that they can have been only appreciated by the carpenter at installation, or today by visitors equipped with binoculars or digital zoom technology. For centuries, worshipers far below would have been oblivious to their existence. The same may be said of a detail on the upper arch braces. The point at which the brace

[38]Later fifteenth-century examples are found in the Norfolk fens at Upwell, St Peter (where the nave was under construction in the 1460s), and Emneth, St Edmund. Further fenland examples are at Landbeach (Cambs.), and in the Lincolnshire, just thirty miles west of Lynn, Pinchbeck, St Mary. Beyond the boundaries of East Anglia, two Lynn-type examples are Addlethorpe Church, on the Lincolnshire coast, and All Saints, Leighton Buzzard, Bedfordshire.

[39] The most current material on King's Lynn St Nicholas is Elizabeth James and Michael *Begley's St Nicholas' Chapel* (London: The Churches Conservation Trust, 2000).

meets the rafter has been embellished with an exquisitely carved polygonal engaged capital. Crenelated, these capitals resemble miniature turrets, and serve to disguise the intersection, and any possible gap, in the hollow moulding of the two timbers. This theme of imperceptible ornament in fifteenth-century hammer-beam roofs will be returned to.

If the Lynn tie-beam framing displays a carpenter combining form and ornament with functional timbers, in the intermediate hammer-beam framing, form and ornament dominate. The hammer beams have little structural function. They are not braced to a wall post to form a bracket (their position above the clerestory windows precludes this), so any structural function they have must be as a pure cantilever. Their section mitigates any cantilever function, however, as they are relatively thin, brattishing making their section appear heavier (Fig. 8.4). Some angels do not appear to be an integral part of the hammer beam, as at Westminster, but seem to be discrete figures, pegged onto the beam. This may be original construction or later repair, but close-quarters inspection would be the only way to verify the truth. Nevertheless, the hammer beam's main function is as a vehicle for carved angels. A visual advantage of such redundant hammer beams is that they require no hammer brace which, entering around the midriff, would obscure the figure. Structural redundancy, then, releases aesthetic vibrancy: the angels can be enjoyed in their full-length splendour.

An important point about these hammer beams is that they constitute a distinct, influential and previously unidentified type. The angels, rather than being carved fully in the round out of the hammer beam timber, as at Westminster Hall, have the appearance of being placed with their backs flat against a panel which forms the soffit of the hammer beam. This upper section of the hammer beam is simply moulded and/or brattished, and serves to frame the angel. I have decided to designate this type a 'panel hammer-beam.' The hammer-beam figures at Mildenhall are extremely similar to those at Lynn, and are of the same 'panel' type. Indeed the panel hammer beam is found in most of the later Type 1.1 roofs, and it seems elemental to the type.[40]

Although much less ornate than Lynn and Mildenhall, Wiggenhall is included in the Type 1.1 'Lynn' category for its geographical and structural cognation (Fig. 8.5). It has the arch-braced queen struts and the un-braced panel hammer beams of Type 1.1. Decorative intent, however, was less ambitious. Subsidiary struts and tracery are absent. The hammer beams are extremely short, and carving is less extensive and though distinctive, of poorer quality. Wiggenhall is contemporary with King's Lynn: either it is a lower-spec copy in an ambitious if poorer parish, or intriguingly, it was a practice piece by a carpenter preparing for the more prestigious, and thus more daunting, commission six miles downriver. If it was the same carpenter, then a different carver was employed, as the hammer-beam figures bear no relationship to Lynn (Figs. 4 & 6). Naively idiosyncratic, they are clearly by a different hand.

Type 1.1 construction with its tie beams should not be judged as the mark of an early structure, the work of a cautious carpenter loath to risk unmitigated hammer-beam construction. Throughout the fifteenth century, carpenters continued to build such roofs, spanning voids which could easily have been managed by non-tied construction.[41] Isleham Church in Cambridgeshire contains a Type 1.1 roof and a rare instance of authorship, the carpenter, or perhaps the donor, supplying the date. Carved on the tie beam is the following inscription: 'Crys-tofer Peyton did mak thys rofe in the yere of our Lord MCCCCLXXXXV being the X yere of Kinge Henry the VII.'[42] Lynn-type carpentry was not, then, a construction imposed upon carpenters by the exigencies of structure, or by inexperience in dealing with hammer-beam framing.[43] Rather, it was definite aesthetic choice.

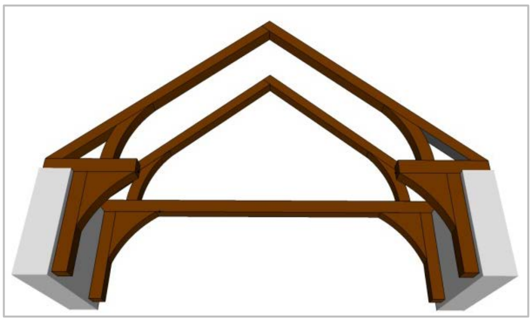
[40] Fifteenth-century Type 1.1 church roofs with panel hammer beams: Isleham, Cambridgeshire; Landbeach, Cambridgeshire, Lakenheath, Suffolk (although the figures are more roundly modelled); Mildenhall, Suffolk; Emneth, Norfolk; Methwold, Norfolk; Upwell, Norfolk; Wiggenhall St Mary's, Norfolk; Addlethorpe, Lincolnshire**.**

[41] The span at Lakenheath, for example, is just 21ft 6in (6.55m).

[42] Edward T. Long, 'Painted Roofs in East Anglian Churches', *The Burlington Magazine for Connoisseurs* , Vol. 55, No. 317 (Aug., 1929), p.75.

[43] See the comments of J. T. Smith expressing a contrary viewpoint, Pevsner, *Suffolk*, 66.

TYPE 1.2. TIE-BEAM /HAMMER-BEAM ROOFS *SANS* QUEEN STRUTS



Debenham and Bildeston have the same basic tie-beam / hammer-beam alternation as the King's Lynn-type, but the framing of these two central Suffolk examples is distinct. (Fig. 8.7). Unlike Lynn, in the intermediate frames the carpenter acknowledged some structural function in the hammer beam (even if belied by the upper framing): a true bracket of hammer beam, hammer brace and wall post support a curved hammer post.[44] The hammer posts spring well back, however, from the end of the hammer beam, and terminate shy of the purlin, so the carpenter did not intend the hammer-beam framing to offer a high degree of assistance to either rafter or purlin. Perhaps the carpenter did not trust the new-fangled construction.

Similar framing is found in the lower portion of the tie-beam frames. Rather than the long, open-spandrelled arch braces of Lynn, short, closed spandrel braces, mirroring those of the hammer-beam frames, assist the tie-beam. Unlike Lynn, these principal frames have no queen struts, and neither did the carpenter think to frame in any collars. He evidently regarded the heavy section of the principal and intermediate rafters as adequate purlin support. Consequently, the principals are left unassisted for approximately two-thirds of their length. I have been unable to find similar roofs that lack both queen struts and collars, so apparently, this type of roof produced no progeny. Perhaps later carpenters thought the carpentry dubious, with all the potential for rafter and purlin sag, but without any compensation of improved ornamental capacity. Today the Debenham roof is held together by an assortment of iron strapping.

[44] Taxonomy is prickly here. Can a 'post' be curved? I refuse, however, to make a major typological distinction between roofs which utilise straight hammer posts arch-braced to the principal, and those which employ broader, curved timbers in that position (often dubbed 'false' hammer-beams). Their structural function is virtually identical: that of strutting the principal.

Visually, the contrast of Debenham with Lynn could not be greater. The aspect is unremittingly dull, dominated by the ponderous tie beams. In the upper framing, no arched queen struts ameliorate the monotony of the rafters. At some point the timbers have been dark-stained, so the carpentry has not even been allowed to age into the silvery-gold patinas of roofs such as Beeston (Norfolk) or Fressingfield (Suffolk) (see figs. 8.16 & 8.17). Even in its polychromed prime Debenham was never the most glorious roof. Rather than recumbent angel hammer-beams, as evidenced by the extant tenons, the sum of Debenham's carving amounted to eight inclined angels or saints morticed onto the ends of the hammer beams (all now lost). An impression of how they must have looked can be gained from Bildeston and its four painted replacements in the east end (Fig. 8.8). Only Debenham's early date renders it worthy of interest and a detour.

Those lost hammer-beam angels are, nonetheless, significant, if irksome, for the hammer-beam researcher. Debenham is the earliest roof to employ these discrete, non-structural figures, and frustratingly, here any argument about the irresistible influence of Westminster Hall stumbles. The Debenham carpenter, working just a handful of years after the completion of Westminster, rejected Herland's monumental constructional figures, and chose to mortice lesser figures to the hammer beams. As the century progressed, especially in Suffolk, such applied figures became the most popular method of ornamenting hammer beam roofs. Later, I will discuss possible reasons why.

TYPE 1.3: GREAT SHELFORD

Finally, mention should be made of the singular roof at Great Shelford Church, Cambridgeshire (Fig. 8.9). Assuming all main timbers are coeval, grappling with the low pitch and the wider than average span (23ft 8in / 7.21m), the carpenter came up with a unique solution and created a confection which defies categorisation. The hammer beams are found in the intermediate frames. They are non-structural, and consist of a 'panel' upper section and a fully modelled lower figure. Thus, though short, they are of the Lynn-type. The Lynn influence is also present in the principal framing, in the ornamental arch-bracing of the queen posts. The principal frames, however, are an odd arrangement: a low arch-braced collar is supplemented by a tie beam. In an instance of carpentered *tromp l'oeil*, the arch braces also appear to be framed into the tie beams, but on inspection, the beams are independent of the main arch-braced carpentry. From their mortices in the wall posts, the arch braces pass over the face of the tie beam and are framed directly into the collar.[45]

This convoluted approach to the principal framing may imply a tentative, 'belt and braces' approach by this carpenter. Perhaps, in the first decade of the fifteenth century, he was handling the new demand for almost flat-pitched roofs for the first time. A low pitched arch-braced collar roof over a wide span would surely have failed, so as a precaution the carpenter inserted the barn-like tie-beams which he then attempted to disguise with the long and broad arch-braces. Such cautious flat-pitched construction connotes an early fifteenth-century date for Great Shelford, which corresponds well with documentary and further circumstantial structural evidence.[46]

THE SIGNIFICANCE OF TYPE 1 ROOFS

Pondering the Type 1 roofs in relation to the other hammer-beam roofs in Table 8.1, it is of major significance that six of the fourteen early examples are not structural hammer-beam roofs. To reiterate, these are tie-beam roofs. The hammer-beams inserted in the intermediate frames are for purely decorative effect. Thus, these early fifteenth-century carpenters perceived ornament as quintessential to their roofs, to be included regardless of structure. While of radically different structural conception, the singular roof at Wingfield Church (*c.* 1415) may be introduced here because it demonstrates a similar ethos.

[45] It ought to be noted that the tie-beams may be a later insertion to control spread in a laterally unstable arch-braced roof of low pitch placed atop thin clerestory walls.

[46] See Appendix 3.

The nave at Wingfield contains a common rafter roof with collars and soulaces (Fig. 8.10).[47] It is a type of construction belonging to a carpentry tradition then centuries old, functioning happily for generations without the carpenter finding it necessary to include hammer beams. And yet here they are. The owner of Wingfield Church in the early fifteenth century was the Second Earl of Suffolk, Michael de la Pole (d.1415). De la Pole was certainly present at Westminster Hall during the revolutionary events of the autumn of 1399, and here, in his family church in the early years of the fifteenth century, we find, arch-braced to common rafters, angel-hammer beams inserted for visual effect.[48] The evidence, then, from the seven non-structural hammer-beam roofs is compelling: in the two decades following the completion of Westminster Hall, patrons were eager to specify angel-hammer beams irrespective of structural need.

TYPE 2: HAMMER-BEAM ROOFS

The remaining eight roofs of the fourteen early post-Westminster Hall examples in Table 8.1 may be grouped initially under the broad category of hammer-beam roofs. Here, rather than the hammer beams being an inserted ornamental feature, as in the Type 1 roofs, the carpenter intended the hammer-beam framing to perform some structural function. This broad category requires refinement, and by doing so we encounter an extraordinary structural divergence seemingly contingent on a geographical feature: the River Waveney.

North of the fluvial border, no Norfolk carpenter elected to frame in the normally desirable collar. Their Suffolk counterparts, meanwhile, chose to include collars in two of their three roofs.[49] The sample in the table is small but indicative, for when the chronology is scaled-up to include Norfolk and Suffolk roofs throughout the later

[47] The most authoritative and recent account of Wingfield Church is found in John A. A. Goodall, *God's House at Ewelme: Life, Devotion and Architecture in a Fifteenth-century Almshouse* (Aldershot: Ashgate, 2001).
[48] Given-Wilson, *Rolls*, 3, 9. A structural note: the arch-braces, consisting of massive single timbers, seemed to be trapped between two common rafter couples.
[49] For the function of the collar in medieval roofs: David Yeomans, *How Structures Work* (Chichester: Wiley-Blackwell, 2009), 184-6.

medieval period, a remarkable picture emerges. Of fifty-two medieval single hammer-beams in Norfolk, forty-one have *no* collars. In Suffolk, of sixty-six single hammer-beam roofs, collars are present in *all* but two.[50] Norfolk practice is curious. Construction with a collar is more stable, providing principal rafter support and thus reducing the length susceptible to potential sag, and providing a point for into which an apex-assisting king post may be framed. The carpenters, even of the very early English roofs, deemed a collar desirable.[51] One might assume that in the early years of what was an experimental roof form, carpenters would have taken pains to incorporate the time-honoured collar to avert structural disaster. Moreover, it was not that the Suffolk carpenter was inept at framing roofs devoid of collars; many arch-braced principal examples exist, especially in chancels.[52] What, then, could account for this extraordinary structural dichotomy?

I propose that post-Westminster Hall hammer-beam construction in East Anglia developed from two distinct structural scions located in major towns. Norfolk carpenters chose to follow the example of St Giles, Norwich (Fig. 8.11), and perhaps later the transepts of Ely Cathedral (Fig. 8.12). In these roofs collars are absent; the principals are arch-braced to a wall post, and rise to a king pendant (discussed shortly). Suffolk carpenters chose to follow the example of St Mary's, Bury St Edmunds, and its more conventional arch-braced collar construction (Fig. 8.13).[53] Indeed, the arch-braced collar, often with a king strut, became routine Suffolk construction in virtually all of the county's subsequent hammer-beams. A notandum here is that, though differing structurally from each other and from Westminster, Herland's influence is still present in these three influential early roofs: all possess ornamental recumbent-figure hammer beams.

Early fifteenth-century Norfolk carpenters, by omitting collars, were pursuing form, and consequently were proving themselves more structurally daring than their

---

[50] Cautley noted the lack of collars in Norfolk hammer-beams, *Suffolk Churches* (1982), 89. The two Suffolk collarless examples are just few miles south of the Waveney, at Bardwell and Whickam Skeith.

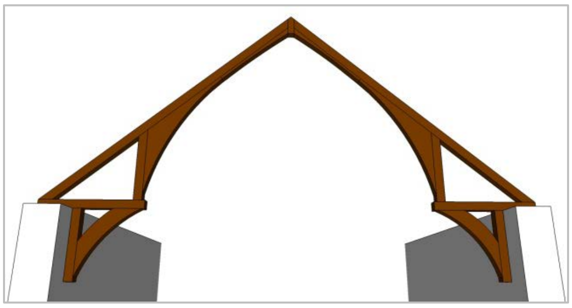
[51] For example, in the modest span in the common rafter roof of the north transept of Wistanstow Church, Shropshire, 1200-21d.

[52] Examples of arch-braced roofs without collars are found in the Suffolk churches of Great Glemham and South Elmham.

[53] Bury lacks an orthodox king strut; the carpenter elected to frame twin struts in this position.

Suffolk counterparts. Indeed, it is remarkable how few of the Norfolk roofs do not suffer from rafter sag. The majority of these collarless roofs have survived the centuries remarkably intact, testament that the craftsman somehow adapted his carpentry to withstand the demands of this new form. Is Norfolk practice a cavalier pursuit of an aesthetic heedless to potential structural catastrophe? The following typology will answer that question.

TYPE 2.1: HAMMER-BEAM ROOFS WITHOUT COLLARS



In probable date order the early collarless roofs are: Norwich, St Giles; Beeston-next-Mileham; Bardwell; Ely Cathedral, South and North Transepts; Great Cressingham. All these roofs have the same basic construction: wall post arch-braced to hammer beams; hammer beams arch-braced to principal rafter; principal rafter arch-braced to ridge. It is in the ridge framing, however, where we find the 'king pendant', the remarkable innovation which freed the carpenter from his bonds to the structural collar.

We can understand this innovation by looking at the splendid roofs over the transepts of Ely Cathedral (Fig. 8.12). These are prime examples of collarless construction and, exacerbating structural challenges, are of fairly low pitch and exceptionally wide span (33ft/10.06m). The massive masonry of the cathedral walls must prevent spread, but what prevents the rafters from sagging? All is conventional in the principal's lower framing: an arch-braced hammer-post provides the stiffening here. In the upper framing the carpenter solved the problem of how to strengthen the rafter by utilising the king pendant (Figs. 8.14 & 8.15). Crucially, the king pendant provides a timber to which the principal can now be braced, thus effectively increasing its section, stiffening it, and allowing the collar to be omitted. Arch-braced now at both ends, the principal is now analogous to timber arch. Embryonic king pendants are framed into the very early fifteenth-century hammer-beam at St Giles, Norwich (Fig. 8.11). Remarkably, in some cases, as at Beeston-next-Mileham and Great Cressingham, rather than brace the principal, the carpenter flared out the section of the rafter, so that 'arch brace' and principal are one timber, and the rafter's functions is even more analogous to an arch (Figs. 8.16, 8.17, 8.47, 8.48).

The king pendant's utility is not confined to the transverse axis. The component also provides an ornamental advantage in the longitudinal aspect of the roof. Here, the king pendant has less structural function in providing a point to which a ridge may be framed. Unlike modern roofs, the ridge in medieval roofs was primarily ornamental. The ridge at Beeston, for example, is located simply by short, un-pegged stub tenons (Fig. 8.18).[54] Usually moulded, the main function of the ridge piece was to mask the unsightly terminations of the common rafters, and frequently it was arch-braced to the king pendant. Framed thus, it introduced a longitudinal arcaded element at the apex which often alludes to similar arcading supplied by structurally superfluous wall post to wall plate arch-bracing. While eschewed at Norwich St Giles, the remaining four early roofs all adopt the formal refinement of ridge arcading, and it was a motif which was to inform the design of many later East Anglian roofs. An extravagant example is found in Carbrooke Church in Norfolk (fifteenth-century), where long king pendants and deep arch-braces accentuate the undulating effect (Fig. 8.19).[55]

An outstanding example of the king-pendant technique is found in the nave of Wymondham Abbey (mid fifteenth-century) (Fig. 8.20). Here the pendants, arch-braced to both principals and ridge, are unusually long and become dominant visual devices. And Wymondham and Carbrooke demonstrate a further ornamental advantage of the king pendant: they permit the application of foliate bosses – at Wymondham deployed on a grand scale. All king pendants of the early type 2.1 hammer-beams are adorned in

[54] I am indebted to architect Ruth Blackman of Birdsall, Swash & Blackman Ltd, Beeston, for supplying me with her drawings of the Beeston roof. The stub-tenon also obviates any pegging difficulties in this four-way joint
[55] Pevsner, *Norfolk 2*, 239, states that the roof is 'late C15', but supplies no reasons for the ascription.

this manner, as are the overwhelming majority of subsequent roofs of this type. A collar is less amenable to this adornment, and if attempted, the results are often clumsy, as at Necton Church, Norfolk (Fig. 8.21).

St Mary's at Beeston is an exception to these early Type 2.1 collarless roofs, as the carpenter here chose not employ the king pendant. The principals are impressively flared, but the framing after that is complicated and difficult to unravel from ground-level. Drawings, completed during the 2006 restoration of the roof, disclose the true structure (see fig. 8.18).[56] In addition to the flare, at the apex the carpenter terminated the principals with a semi-circular distension, which, when the principals were coupled, resulting in a form analogous to a masonry boss (Fig. 8.16). Rather than halving or bridling the principals here to form the coupling joint, as would be normal practice, the carpenter morticed both timbers and inserted a loose tenon. Thus, although principally an ornamental refinement, the 'boss' permits a more substantial section for the principals to be pegged, both to the loose tenon and to the ridge, so managing pegging difficulties in the always problematic four-way joint. Further, the ridge is arch-braced to the principal frames as at Ely, but without the pendant post, the carpenter was forced to simply trap the halved arch braces between the principals. Nevertheless, a tremendous amount of labour went into fashioning this joint.

Is this somewhat untidy construction at the apex evidence of the Beeston carpenter struggling with a construction he had yet to master, or even discover: the king pendant? Perhaps he was unfamiliar with the contemporary roof at St Giles and its king pendants. Or are those boss-like bulges at the ends of the principals his own, individual and experimental, solution to the problems of ornamental apex framing? Judged by the flaring of the principals and other details indicating a carpenter of some proficiency, the latter is more likely.

[56] Blackman drawings.

Type 2.1 Hammer-Beam Roofs and The Function of Form

Evident, therefore, in these Type 2.1 roofs, is the ingenuity and creativity of the Norfolk carpenters, driven by their desire to remove the collar. The authors of these roofs were interested in form, in creating a clear longitudinal vista high in the nave of a church uncluttered by horizontal timbers (Fig. 8.22). But how was that form intended to function?

Such unobstructed arcuation functioned to lead the eye towards the most sacred part of the church, but not to the chancel, the domain of the priest. Screened off from the people, this was the incense-obscured realm from which emanated Latin incantations largely incomprehensible to the lay. Rather, the liturgical and visual cynosure for the laity in a medieval parish church was in their own, less sacred, part of the church: the nave. At the east end of their realm, placed aloft, above or in the tympanum of the chancel arch, was the symbol of their salvation: the holy rood. All medieval churches had a rood.[57] Christ crucified was the rood's most simple form, but the redeemer was often flanked by two other figures, the Virgin and Saint John. For the laity gazing eastwards during the mysteries of the mass, the composition dominated the vista. Although modern (1934), the example at Wymondham Abbey gives some impression of the visual authority of the rood (see Fig. 8.20).

To the lay, the rood was a deeply personal symbol of their salvation. Before the rood was where the he received the holy sacrament of the Eucharist.[58] It was the culminating point of the most elaborate and important ritual of the year: the Easter procession and mass.[59] Before the rood was where the second of three key stages of the sacrament of marriage took place.[60] Beneath the rood was the burial spot for lesser worthies not deemed sufficiently holy for the chancel and who had not the means for a private chapel, and during the funeral service, there the bier stood. Behind the rood, painted on a wooden tympanum or on the chancel arch itself, was further iconographic

[57] For roods see Aymer Vallance, *English Church Screens: Being Great Roods, Screenwork & Rood-Lofts of Parish Churches in England & Wales* (London: Batsford, 1936), 1-12.
[58] Eamonn Duffy, *The Stripping of the Altars* (New Haven & London: Yale University Press, 2nd ed., 2005), 94.
[59] Duffy, 25, 26.
[60] Northeast, 100, 102.

material: that unequivocal portrayal of empyrean salvation or monstrous damnation, the Doom (Fig. 8.23).

The eschatological carrot and stick of the Doom formed the backdrop for most roods (Fig. 8.24).[61] Most have now been lost, but the few that remain reveal the imagistic dynamite they must have been for the parishioners: 'he shall have accusers above him, within him, on either side of him, and under him … above him shall be Christ his domesman so wrothe … under him hell zawning and gaping and spitting fire and stench ready to swallow him into the pain that shall never end.'[62] Devils herded the damned into the gapes of toothsome monsters to be then 'gyuyd in fyry feturs and hangyd vp in the myddys of fyre on gybbetis, home the cruel tormentours and fyndys alto bete and brake with scorgys and forkys and vpbrayde hem of crymys and synnys with great scornys and mockys.'[63] Contrasted with these scenes of perdition were less lurid depictions of the saved. On the right hand of Christ enthroned in glory these are led by angels to celestial bliss. In the Doom, the destiny of souls was laid patently bare in either glory or gore. The message of these images is unambiguous, but the words of St Hugh of Lincoln précis the function of such terrible propaganda: 'One should keep the thought of these eternal pains before one's mind all the time … In this life we still have a chance to avoid this terrible fate, and to do so we ought to dread it with our whole being.'[64]

Continuing the spiritual propaganda, beneath the rood and the doom was the screen, with its exempla: painted panels of saints and holy men. Above, and increasingly installed as the fifteenth century progressed, was the rood loft. Again, most of these structures were destroyed by iconoclasts, but evidence of their existence is found in many parish churches at the base of the chancel arch, by cramped staircases which lead nowhere, or open out onto the void of the arch. Usually the work of the carpenter, rood

[61] Colin Platt, *The Parish Churches of Medieval England* (London: Secker & Warburg, 1981), 120-6; Vallance, 16-26; A. Caiger-Smith,*English Medieval Mural Paintings* (Oxford: Clarendon Press, 1963), 37-43.
[62] *John Mirk's Festial*, ed., Susan Powell, Vol. 1, (Oxford, Early English Text Society, 2009), 6; translation in Caiger-Smith, 42; Platt, 122.
[63] Edward Arber (ed.), 'The Revelation to the Monk of Evesham', in *English Reprints* (London: Edward Arber, 1869), 83.
[64] Caiger-Smith, 41

lofts were galleries functioning for the musical enrichment of the liturgy.[65] Here, the deacon chanted the gospel on great feast days. During the Easter Mass, the gospel was sung by clerks positioned in the rood loft.[66] On Easter eve, either from the pulpit or the great rood, the deacon began the chant with the words, '*exsultet iam Angelica turba coelorum*' ('Now let the angelic heavenly host exult'), words whose potency would have been intensified by any angelic host arrayed in the roof above, some with their gaze turned encouragingly, or is it reprovingly, to the flock below (Fig. 8.25).[67]

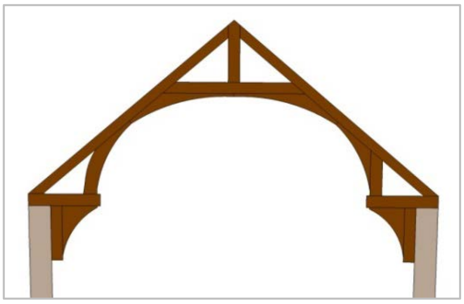
Combined, the rood, its screen and loft, and the doom, made both simple and complex doctrine of blessed mercy and eternal torment palpable to the people in their part of the church. No doubt pondered during the slower parts of the lesson, the key themes of redemption were all there: Christ impaled: the redeemer of mankind; Christ in majesty: judge of mankind; the saved and the damned, and on great feast days the tableau to be then augmented by angelic voices. Much imagination, craft and money were invested in such an elaborate didactic display. It would be wise to requisition all devices to focus attention on the iconography – including, I would argue, the roof carpentry. The cadence of receding gothic arches, uninterrupted by collars, would serve perfectly to draw the eye towards and frame these devotional cynosures.[68] How much better if this vista was further focussed by a twin rank of observing hammer-beam angels: '*exsultet iam Angelica turba coelorum*.'

The hammer-beam roof trefoil further answered and framed the triple nature of the rood and alluded to the trinity. And, just as in Westminster Hall where a trefoil served to focus the gaze on a deified Richard II, so the tri-lobed tunnel of the hammer-beam roof in a parish church performed a similar function. Earlier roofs with tie-beams would have interrupted the view; common-rafter roofs with their soulaced collars or

[65] For a discussion of screens and lofts see Vallance (1936), 48-56, 66-85, and his *Greater English Church Screens* (London, New York: B.T. Batsford, 1947), 1-26.
[66] Duffy, 26.
[67] Peter & Linda Murray*, The Oxford Companion to Christian Art and Architecture* (Oxford: OUP, 1996), 174, 452. Examples, among others, of the final pair of angels turning their gaze to the congregation are in the Ely transepts; Cawston, Norfolk; Great Cressingham, Norfolk; Wingfield, Suffolk.
[68] See the comments of Geoffrey Webb, *Architecture in Britain: The Middle Ages* (Harmondsworth: Penguin, 2nd ed., 1965), 190.

scissor braces might supply an open vista, but they amorphously lacked the grandeur, the image-affixing potential, of the more solid and defined trefoil forms of the hammer-beam.

Type 2.2: Hammer-Beam Roofs with Collars


[69]

The final distinct type of hammer-beam roof now remains to be considered, and it was the type which especially in Suffolk was to become most ubiquitous: Type 2.2, 'hammer-beam roofs with collars.' Although the most common form in East Anglia and beyond, it is little represented in Table 8.1 with just two examples from the first three decades of the fifteenth century.

If, as proposed earlier, St Mary's, Bury St Edmunds, was the progenitor of this type of roof, then later Suffolk craftsmen could not have possessed a more splendid model (see fig 8.13). Here, carpentry transcends mere constructive principals and becomes truly an art-form. A prodigious craftsman created a work of greater formal refinement than Westminster and of more ornamental sophistication than the Norfolk collarless roofs. Curious it is, then, that its adoption and adaption by later Suffolk carpenters became so mundane. St Mary's structure is as follows: principal hammer-beam frames alternate with arch-braced frames, a not uncommon arrangement in hammer-beam roofs, at Bury each frame serving to further articulate the subdivided bays created by a doubling of the clerestory windows. Relatively slender hammer posts are arch-braced to the principals at their junction with the lower of two tiers of purlins.

[69] The cross-frame shown here is a synthesis of two sub-types: the hammer post on the right is arch-braced to the principal, in the example on the left, the brace and post are merged into one curved timber. Both constructions are found in Suffolk roofs.

From this point a further arch brace rises to the lofty collar. Rather than a short king post, the Bury carpenter inserted two struts from collar to principals, which further serve as frames for tracery (Fig. 8.26). No vertical timbers are structurally essential in this position: as at Lynn, in the remoter, barely discernable reaches of the roof, this is the carpenter delighting in the deployment of pure ornament. A visual drawback of such collared construction is that, in contrast to the Type 2.1 Norfolk collarless roofs, the collar inevitably flattens the crown of the gothic arch, resulting in a form more domical and Romanesque in character. In compensation, long wall posts accentuate the sweep of the uninterrupted arch in the intermediate frames, and of the trefoil in the principal frames. The Bury roof then, is a structure of some elegance and grandeur. Its basic formal theme was repeated in the majority of subsequent Suffolk roofs, albeit with much diluted splendour.

While the carpentry delivers a structure of substantial dignity and grandeur, the main joy of Bury is its sumptuous sculptural programme (Fig. 8.27). Indeed, the Bury carpentry exists as ground for carved ornament. Relief and figure carving abound, and of consummate craftsmanship, on a par with recherché work at Mildenhall and Beeston. A painting of *c.* 1710 shows the recumbent angel-hammer beams still capitated, so the medieval figures had survived two centuries of iconoclasm relatively unscathed.[70] In each cross-frame, the hammer beams, with exception of minor detailing, are paired in opposition, and various attempts have been made to identify and interpret the figures. The final, most eastern pair have been identified as either the Virgin Mary with, opposite, the risen Christ, or, Margaret of Anjou, and Henry VI in regal majesty.[71] The rest of the figures, rather than the generic examples of many hammer beams, are also individualised, representing, for some scholars, clergy and their assistants vested for the celebration of high mass, for others, participants in the popular late-medieval narrative

[70] In Clive Paine, *St Mary's Bury St Edmunds* (Bury St Edmunds: Honey Hill Publishing, 2000), unpaginated.
[71] John Hamilton Sandford, *A Description of St. Mary's Church, Bury St. Edmunds* (Gloucester: British Publishing Co., 10th ed., 1962), 10-12; Anon., *The Angel Roof, St. Mary's, Bury St. Edmunds*, (Bury St. Edmunds: 1955), unpaginated; J. B. L. Tolhurst, 'The Hammer-beam Figures of the Nave Roof of St. Mary's Church, Bury St Edmunds', *Journal of the British Archaeological Association*, Series 3, Vol. 25 (1962), 69-70; Paine.

of the Coronation of the Virgin.[72] Further, instead of objects usually associated with hammer-beam angels, such as the instruments of Christ's passion and musical instruments, they bear liturgical items. Some bear chalices; others censers, candlesticks and gospel books (Fig. 8.28). Garbed thus, and in a society where images occupied a hinterland between the animate and inanimate, they were intended not as mere passive observers, but as participants in the liturgy taking place below, a procession on its way to the sanctuary.[73]

Subsidiary carving is of even finer quality. The cornice carries two tiers of demi angels, the majority again individualised (Fig. 8.29). The wall posts house forty-two figures of saints and prophets sheltered by carved capitals (Fig. 8.30): St Joachim carries a basket of turtle doves; St James the Great is on pilgrimage, with his pilgrim's hat, travel pouch and staff, toes clearly peeping out from his sandals; St Simon (or possibly St James the Less) bears the saw of his martyrdom, as does St Andrew with the saltire; St Michael dispatches the dragon.[74] All these wall-post figures are carved with precision, are roundly modelled, and are clad in draperies of such delicacy, the folds appear they might ripple should a breeze enter the church. Further, the carvers were not content to embellish only the more prominent components of the church. Indeed, over eight hundred highly accomplished carvings adorn the nave and aisles of this church. All hammer-beam spandrels are adorned: the open spandrels above and below the hammer beams are filled with tracery replete with figure carving, and on the upper framing, the solid surfaces of the arch-braces are relief-carved with foliate designs or creatures – all stylised, some bizarre.

---

[72] Tolhurst, 67, 69; Sandford, 12; Gail McMurray Gibson, *The Theater of Devotion: East Anglian Drama and Society in the Late Middle Ages* (Chicago; London: University of Chicago Press, 1989), 170-5;

[73] For images working miracles and coming to life: Theodor Erbe (ed.), *Mirk's Festial: a Collection of Homilies, by Johannes Mirkus (John Mirk*) (Kegan Paul, Trench, Trubner for EETS, 1905), 297; W. O. Ross (ed.), *Middle English Sermons*, (Oxford: OUP & EETS, 1940), 209; Margaret Aston, *Faith and Fire: Popular and Unpopular Religion, 1350-1600* (London: Hambledon Press, 1993), 267, 269, 272; Aston, 'The Use of Images', in *Gothic: Art for England 1400-1547*, eds. Richard Marks; Paul Williamson (London: V&A Publications, 2003), 73; Robert Swanson, *Catholic England: Faith, Religion and Observance Before the Reformation* (Manchester: Manchester University Press, 1993), 178-9.

[74] For the identity of the wall-post figures see Samuel Tymms, *An Architectural and Historical Account of the Church of St. Mary, Bury St. Edmunds* (Bury St Edmunds: 1845-54), 170-1.

The carpenter adapted his carpentry to augment the sculptural program. In the intermediate frames, he chose to alter the time-honoured structural certainty of the arch-braced wall post to principal. At first glance it appears that, at wall plate level, he divided the arch brace with a horizontal timber. Cautley thought this component an embryonic hammer-beam.[75] Closer inspection reveals an adaption of the sole piece, the horizontal timber normally tenoned into the back of the wall post. Here, the carpenter increased the section of the sole piece, lengthened it so that it passed across the wall post, and then bridled it over the arch brace (Fig 8.31). It is difficult to find a function for this modification other than ornament. The carpenter evidently wanted to supply yet another surface for carving, even in these dark corners.[76]

Carved on the bridled sole pieces, still stranger entities lurk (Fig. 8.32). Compared to the beings occupying the more prominent areas of the roof, the creatures inhabiting these shadowy corners descend in sanctity and ascend in profanity. Wolves, cats and apes preside. A naked doctor proffers a flask, a charlatan perhaps. At the east end, immediately adjacent to the canopy of honour and between the Virgin and the risen Christ, and in typical medieval juxtaposition of the sacred and profane, a pair of naked, hirsute, woodwose emerge from the forest wielding clubs. Indeed, viewing the sculptural program of St Mary's as a whole, a definite iconographical hierarchy emerges. Celestial, deific figures constitute the main structural hammer-beam timbers; lesser saints and holy men occupy the wall posts below; and a menagerie of beasts and a variety of flora occupy the darker recesses, with the basest figures reserved for the angles of arch-brace and wall plate. Such placing of the more profane subjects to the margins of the framing is analogous to the irreverent marginalia of contemporary manuscripts.[77]

More intriguingly, could the sculptural hierarchy express the framing hierarchy? For example, the arch-braced frames play a lesser structural role than the angel hammer-beam frames, and, lacking the angel hammer beams, they similarly play a lesser

[75] Cautley, *Suffolk*, 94.

[76] The bridled sole piece is a rare technique, but it can be found in the churches of Little Welnetham and Hawstead, Suffolk, and Necton in Norfolk.

[77] For medieval manuscript marginalia see Michael Camille, *Image on the Edge: The Margins of Medieval Art* (London: Reaktion Books, 1992)

ornamental role. As another example, the carver cutting the more profane subjects at the feet of the angel hammers in the principal frames might have seemed a sacrilegious step too far, but locating them on the bridled sole piece of the intermediate frames, frames of lesser structural significance, was perhaps a more fitting location.

If the structure created by the Bury carpenter was to influence later Suffolk craftsmen, then so was his pursuit of ornament. Subsequent roofs were to lack the opulence of the St Mary's hammer-beam, but later carpenters were to take their cue and adapt their own structures in the furtherance of a sculptural program. The Bury carpenter's bridled sole piece may have had negligible effect on the stability of his hammer-beam roof, but as the fifteenth century unfolded, his county colleagues began to experiment with more crucial structural components in the pursuit of ornament.

The Decline of Structure and the Triumph of Ornament

In the quest for more devotional imagery, it was to the lower hammer-beam framing that Suffolk carpenters applied their imaginations. In the trilateral area formed by the East Anglian towns of Ipswich, Bury St Edmunds and Gestingthorpe, a minor industry existed in the production of pendant-post hammer-beam roofs.[78] This type of configuration may be explained thus: in conventional hammer-beam construction the hammer post is tenoned vertically into the hammer beam. In pendant construction the hammer beam is tenoned horizontally into the hammer post (Fig. 8.33). It is a construction of negative structural implications. Pendant configuration means that on square timbers of a section of, for example, 8in (210mm), any shearing force the beam is intended to carry rests on a 1½in (40mm) tenon rather than its full 8in width as in conventional construction. Further, under certain lateral wind-loading conditions the mortice and tenon joint may now go into tension (conventionally it sat happily in compression), and any forces this triangulation (with the principal rafter) is meant to control depends merely on the one-

[78] Pendant post hammer-beam roofs are found in the following Churches (Suffolk unless stated otherwise): Wetherden, Cotton, Earl Stonham; Grundisburgh; Tostock, Gestingthorpe (Essex). The list is not comprehensive.

inch (25mm) pegs locating the joint and the poor resistance to shear of the short-grain tenon (Fig. 8.34).[79] Nonetheless, carpenters persevered with this structurally suspect construction, the pendant post favoured even in the august royal setting of Eltham Palace (*c.*1475-79). Why?

The pursuit of ornament was the driver. By now we are in the mid-fifteenth century, and any influence of Westminster Hall has waned. The notion of the hammer-beam roof as a vehicle solely for angel-hammer beams has been abandoned and other visual motifs gain favour. Indeed, pendant-post construction, unless the roof is a double hammer-beam, precludes the recumbent angels of Westminster Hall. One of these motifs was the ornamental wooden 'boss.'[80] During the fifteenth-century, ornate bosses, often foliate in nature, became a common feature of East Anglian roofs. These were frequently mounted at the intersection of the purlin with the principle and intermediate rafters, and on the underside of king pendants. Wymondham Abbey contains some particularly extravagant examples (Fig. 8.20). Pendant-post carpentry allowed the carpenter to move such ornament at a lower, more visually dominant level.

If the suggestion of a descended boss as a stimulus to pendant-post construction seems glib, then consider another ornamental catalyst. The date of the hammer-beam roof in Tostock Church, Suffolk, probably corresponds with the remodelling of its nave in the mid fifteenth century (Fig. 8.35). If so, then Tostock is the earliest pendant-post hammer-beam roof in England. Tostock's fine hammer-beam is also significant because it displays a further ornamental advantage of the pendant post. In its lower section, the carpenter created a niche, and in that canopied space he carved a saint (all decapitated during iconoclastic purges) (Fig. 8.36). Such figures are common denizens of the wall posts of East Anglian roofs, but the pendant post supplied added, more perceptible locations for these devotional figures, from which their exempla could be more profoundly apprehended.

---

[79] For the effect of wind forces on roof structures, see Yeomans, 180; also, Jack Sobon & Roger Schroeder, *Timber Frame Construction* (North Adams, Mass.: Storey Books, 1984), 88. Rather than the end-grain shearing, the pegs can also suffer significant bending, which would also destabilise the joint, Peter Ross, et al, *Green Oak in Construction* (High Wycombe: TRADA: 2007), 163.

[80] These ornamental timber 'bosses' have no structural relationship to the masonry boss.

A further twist (pun intended) in the framing at Tostock demonstrates a final stage in an astonishing turnaround in carpenters' priorities during the later Middle Ages: from rational and prosaic construction, to the ascendance of form and ornament. In contrast to the conventional pedant-post framing, at Tostock the carpenter rotated the hammer post by 45° and framed it arris-first into the hammer beam (Fig. 8.37).[81] Such construction meant that the layout and scribing procedures at the framing yard were rendered more problematic. The carpenter had to cut a vee at the end of the hammer beam, scribed to the form of the rotated hammer post, and still create a tenon within that vee. A mortice then had to be chopped into the arris of a hammer post presumably secured by chocks. Such construction also compromises the strength of the joint. To engage any substantial section of timber in the hammer post, the peg locating the joint can only be positioned near the end of the hammer beam tenon and its oblique shoulders, and thus the risk of the end-grain shearing under any tensile force is greatly increased. Mortice and tenon joints are normally fixed with at least two pegs, but astonishingly, as the section of the Tostock hammer beam diminishes because of its heavily moulded profile, the carpenter was only able to secure the joint with one peg (Fig. 8.38). Nonetheless, the Tostock carpenter was willing to incorporate these structural compromises and increase framing difficulties. Why? In order to accommodate his sculptural programme. An arris-framed hammer post (author's designation) allows the carver greater depth of timber in which to create his niche and to carve a more roundly modelled, three-dimensional occupant. At Tostock, if the conventional, non-rotated, configuration had been maintained, the hammer-beam tenon would have protruded somewhere in the vicinity of the saint's nose.

Nowadays, Tostock seems a modest roof. Timbers are simply moulded, and simple is the tracery which adorns only the interstices of hammer beam, post and principal. But the modern sober appearance belies the fact that this was once a roof of great splendour. Denied their traditional position on the end of the hammer beam by the pendant posts, angels once adorned the ends of the hammer beams in the upper tier,

[81] The only other example of this technique I have thus far identified at Cotton Church, Suffolk

for Tostock is a double hammer-beam roof. Add the painted finish typical of such roofs of the period, with all the figures picked out in polychromatic finery, and Tostock must have been a structure of a high degree of visual sophistication and artistry. Nevertheless, with such a rotated pendant construction, the hammer-beam carpentry was losing much of its structural function. Ornament was now king. One is left to conclude that the hammer post is offering no sustenance to the principal, and that the formally dominant hammer-beam framing is structurally useless – the timberwork merely suspended from the rafter. Just such a philosophy, of disregard for structure in the quest for ornament, was to lead to the nadir of fifteenth-century hammer-beam construction, and in a surprisingly august setting.

It is remarkable that no hammer-beams roofs are found in ecclesiastical buildings before Westminster Hall, whereas, post-Herland, once the divine decorative potential of the hammer-beam roof was unveiled, the overwhelming majority of hammer-beams were erected in churches. One of the few secular examples is located in the Great Hall of former Royal Palace at Eltham, Kent (Fig. 8.39). Carpentered for Edward IV between 1475 and 1479, the roof is a riot of ornament. All major timbers are heavily moulded; serpentine cusped wind-braces in three tiers adorn the longitudinal elevations, while panel tracery fills the voids in the cross-frames. An apparently continuous arch rib alludes to Westminster Hall, but, of flattened form and heavy section, it is ill-conceived. The roof is of pendant-post construction, and here the carpenter delighted in illusion. By adding mouldings, he made the bulky hammer beams appear functional, and apparently suspended from the ends of each are traceried decagonal cage-like structures, terminating in five-tiered drop-finials (Fig. 8.40). These pendant cages rise to a moulded wooden capital, intended to appear a solid part of the hammer beam, but in reality consisting of separate bevelled sections, simply nailed on, the 'capital' serving to mask the junction with the pendant post. Above the capital, attenuating the bulk of the hammer post, are engaged 'shafts', but square in section, their bands of moulding replicating those of the 'cage' verticals.

Ornamentally the roof is a display of exquisite craftsmanship executed by a carpenter with an eye for detail. Structurally it is one of the most incondite roofs ever carpentered for a high-status client. For a long period it was deemed fit to shelter, not grandees, but agricultural paraphernalia. [82] The shortcomings of pendant construction have already noted, and the Eltham hammer-beam framing is indeed structurally redundant, 'upheld' by the principals. Moreover, further design decisions compromise the roofs stability.[83] The wall-post / hammer-beam bracket, longer horizontally than vertically, is structurally the wrong way round, and exerts tremendous thrust on the top of the walls.[84] A moment's monocular sighting up the internal face of the wall confirms that the masonry is significantly pushed out of plumb. It was not, as at Westminster Hall, the appetite of the death-watch beetle which compromised the Eltham roof. It was the carpentry. In the Eltham pendant hammer-beam roof, ornament triumphs over structure, and critics over two centuries have dismissed the roof with excoriating contempt.[85] The observer does not have to peer too hard to discern Frank Baines's steelwork holding it all together (see Fig. 8.50). If the scholar finds it necessary to use the modifier 'false' with regard to hammer-beam construction, then perhaps here the opportunity.

[82] 'On this honoured station are now seen the various instruments of agriculture', John Chessell Buckler, *An Historical and Descriptive Account of the Royal Palace at Eltham* (London: 1828), 76. At the death of Charles 1 the roof was 'whole out of repair', and fit only for the 'servile purposes of a barn', H. Dunnage & C. Laver, *Plans, Elevations, Sections, Details, and Views, of the Great Hall of the Royal Palace of Eltham, in Kent* (London: J. Taylor, and Priestley & Weale, 1828), 7. The structure of the roof is disclosed by drawings in this book.

[83] Dunnage & Laver, 16.

[84] Simple calculations can be made to prove this, but anyone who has ever put up a shelf bracket knows that disaster is more likely averted if the longer section is screwed to the wall.

[85] See the comments of Sir Frank Baines, HM Office of Works, quoted in Cescinsky & Gribble, *Early English Furniture and Woodwork* (London: The Waverley Book Company Ltd., 1922), Vol. I, 83-85; and carrying perhaps less authority, those of Thomas Morris, *Brief Chapters in British Carpentry* (London: Simpkin, Marshall & Co., 1871),74-76.

THE LEGACY OF WESTMINSTER HALL

The reader may be perturbed at this point because, in my enthusiasm to discuss fascinating fifteenth-century developments, the stated purpose of this chapter, the influence of Westminster Hall on subsequent hammer-beams, has been somewhat ignored. Based on of my typology and structural and ornamental details elucidated in the preceding discussion, this deficiency is now addressed.

Perhaps the most surprising aspect to come out of this study of post-Westminster Hall hammer-beams is just how limited the influence of the structure and ornament of Herland's great hall really was. The form of the balanced trefoil combined with a dominant, heavily-moulded great arch rib was rarely attempted in any of the subsequent two-hundred or so fifteenth-century hammer-beams. The carpenter at 'Imberhorne', (Fig. 8. 41) East Grinstead, West Sussex (1428d), was evidently familiar with Herland's work, since a hammer-beam frame in the hall there bears a striking resemblance to the form of Westminster Hall. Carpentry, however, is radically different, and the same is equally true of another roof ostensibly similar to Westminster Hall, the Exeter Law Library (1420-22d).[86] According to Francis Blomefield, the Great Hall at Oxburgh Hall, Norfolk, had a Westminster-like hammer-beam. He reported: 'opposite to the *great tower* on the south side of the *court*, stands the hall, in length about 54 feet, and 34 in breadth … the roof is of oak (in the same style and form with that of *Westminster*) equal in height to the length of it, and being lately very agreeably ornamented and improved, may be justly accounted one of the best old *Gothick halls* in *England* [italics Blomefield's].'[87] The Oxburgh roof was destroyed in the nineteenth century and, apart from Blomefield's reference, its form is unknown.

From the known and extant evidence, then, it is curious so few medieval carpenters tried to emulate Westminster. Perhaps the carpentry was just too demanding,

---

[86] For Imberhorne, see J. Clarke, 'An Early Vernacular Hammer-beam Structure: Imberhorne Farm Cottages, East Grinstead, West Sussex', *Vernacular Architecture* 36 (2005), pp. 32-40.; For Exeter, Cescinsky & Gribble, 91– 4; John Walker (ed.) *The English Medieval Roof: Crownpost to Kingpost* (Essex Historic Buildings Group, 2011), 108-110.

[87] Blomefield: *An Essay towards a Topographical History of the County of Norfolk:* (London: William Miller 1805-10), Vol. 6, 168-197. The roof was destroyed in the nineteenth century.

too full of esoteric techniques kept in mystery by Herland. As we have seen, many Norfolk carpenters, in the quest for a loftier arch, even ignored the arch-braced collar structure of Westminster. Other carpenters preferred the form and ornament of the Type 1.1 roof: tie beam with queen posts. The carpenters at Lynn probably concluded that the nave's unusually wide span of 32ft (9.75m) demanded a tie beam, but then rendered it as ornate as possible. Mildenhall and the later roofs have a much narrower span, a span in other churches comfortably bridged by un-tied roofs. Nonetheless, the impact of the Lynn aesthetic was evidently so great that those carpenters, choosing to ignore the model of open-span Westminster Hall, opted for a low pitch and the ornate tie-beam. Westminster Hall, then, was a medieval one-off, a work of genius by a carpenter/designer whose revolutionary design demanded by the exceptional span was well beyond the techniques of the average local carpenter. Its grand design was, in any case, perhaps deemed unfitting for a parish church.

Nevertheless, Herland's great hall was not devoid of influence. The Westminster hammer-beam unleashed a client demand for the insertion of angel-hammer beams, and as we have seen, regardless of structural need. Thus, they occur in the Lynn-type tie-beam roofs and the Wingfield common-rafter roof. Ten of the fourteen early hammer-beam roofs in Table 8.1 feature recumbent angel-hammer beams, and in six of them they fulfil no structural need. Even here, however, carpenters departed from the Westminster model, and in all six instances of redundant hammer beams they created panel hammer beams, figures which, rather than being carved fully in the round, lie as though on flat panels.

And then what are we to make of Debenham, one of the very earliest roofs, and Bardwell of just a few years later, with their short moulded hammer beams and applied hammer-beam figures (Fig. 8.42). The renown of the grand figures of Westminster Hall apparently left no mark on the parishioner clients' consciousness, as here they rejected the Westminster recumbent angel-hammer beams completely. It is perhaps here one should analyse the difference between the applied and the structural figures, and why, as the fifteenth century progressed, the applied figure became the ornamental device most commonly found in fifteenth-century hammer-beam roofs (Fig. 8.43).

The increased use of applied, non-structural figures, instead of the Westminster-type carved structural hammer-beam timbers, was driven by factors pertaining to the efficiency and economy of the framing process. In the case of the Westminster-type carved constructional timbers, prefabrication meant that the timbers would be laid up, scribed and cut, test-assembled, then dismantled. Only on completion of this process would the hammer beams then be carved. Carving the figures before framing commenced would render difficult the laying up, the plumbing and levelling of the timbers and the creation of reference points, because three flat surfaces normally available to work from would be occupied by carving. Scribing to a carved surface would have been prohibitively time consuming and would have demanded an inordinate amount of skill on the part of the carpenter. In theory, the carver could have fashioned the hammer beams following installation, but it is unlikely that it became practice for the carver to climb a scaffold and then suffer the discomfort and inconvenience of working on the carving upside-down. The hammer beams, then, must have been carved between the completion of the prefabrication, and erection on site. If carver or carpenter of adequate skill was not part of the carpenter's immediate employees, then the hammer beams would have to be carted away, or more likely, a carver hired subject to his availability. It was a trepidatory commission. Botched, and a main structural timber, fully jointed and prepared by the carpenter, would be ruined, and the framing process would have to begin again. In short, the incorporation of full-length structural figures was a time consuming, daunting process, in which the carpenter was reliant on others for the completion of his frame.

East-Anglian carpenters employed two options to streamline the above process. In some roofs, for example Holme Hale in Norfolk, the carpenter used recumbent demi-figures (Fig. 8.44).[88] Here, the carving is still part of the main structural timber, but is

[88] Other examples of this technique are found in the north aisle of Wymondham Abbey, and Bramford Church, Suffolk. Herland's angels, of course, are full length, their cloud obscured feet forming an abutment to the curved strut.

limited to the extremity of the hammer beam beyond the intersection of hammer brace and hammer post. Any scribing difficulties are thus avoided, and the figure may be carved at any point during the framing process. The other option, far more commonly employed, was the use of the applied discrete figures, as at Debenham. With such applied figures, carpentry is even more straightforward. The roof could be prefabricated at the yard conventionally with no mind to carving structural timbers. At some point, the carpenter simply had to fashion tenons on the ends of his hammer beams for the smaller figures, carved elsewhere, to be then morticed and attached following erection. Such a process lends itself to mass production. The smaller figures could be manufactured by specialist carvers working in smaller workshops independent of the framing process, and then be bought by the carpenter to attach when convenient. The carver might create a stock of popular figures, for either himself or the carpenter to hold.

The economic structure of medieval society supports this argument for such a streamlined approach. Medieval towns were the centres of artisanship. In East Anglia, both Norwich and Ipswich were flourishing towns in the fifteenth century, and their prosperity was reflected in their extensive church-building campaigns.[89] Norwich was England's second city, and possessed the extraordinary number of forty-six parish churches.[90] Between the fourteenth and early sixteenth centuries almost every one of these churches was rebuilt on a grander scale, a frenzy of building mirrored across the county border in Ipswich, where all of the town's eleven churches were rebuilt during the 150-year period to 1551.[91] Add to this a parallel industriousness in secular building, and Ipswich and Norwich must at times have resembled huge building sites.[92] With so much church-building going on in Ipswich, notwithstanding any items for private devotion, the demand for images in a small, local area must have been immense.

[89] For the economic prosperity of Ipswich: Nicholas R. Armor, *Late Medieval Ipswich: Trade and Industry* (Woodbridge: Boydell, 2011), 24.
[90] London had just over twice as many churches, but for over five times as many people, Norman P. Tanner, *The Church in Late Medieval Norwich* (Toronto: Pontifical Institute of Mediaeval Studies, 1984), 2-3.
[91] Tanner, 4.
[92] Armor, 206; also L. J. Redstone, *Ipswich Through the Ages* (Ipswich: 1969), 73-74.

It must be remembered here the centrality of images to pre-reformation religious devotion. The modern-day authority on the English Reformation, Margaret Aston described it as an age 'saturated with images'.[93] Walking into a medieval church today, one gets only an inkling of the amount of imagery with which the church would have been crammed. Every niche, window and capital was an opportunity for the display of images, to which a prayer could be said or an offering made, from a lighted candle to jewellery.[94] While in the great churches much of this carving would have been executed in stone, in less grandiose parish churches, wood was the more fitting medium. Thus, during sixteenth-century bouts of iconoclasm, images were frequently referred to as being burned.[95] The focal image of the nave of every parish church, the rood, and also the any imagery associated with the rood screen and loft, were crafted usually by the woodcarver.

A sizeable population of craftsmen was thus necessary to service this demand, and original records reflect this. Following his study of contemporary Ipswich borough records, V. B. Redstone concluded that, by the second quarter of fifteenth century, Ipswich was populated by 'mainly craftsmen and artisans.'[96] Records show that citizens were letting out their agricultural land for a nominal rent in favour of the pursuit of more profitable enterprises, such as manufacture of crafted items.[97] A proportion of these artisans would be woodcarvers. Records from the Ipswich petty courts show, unsurprisingly, that woodcarvers were resident in Ipswich, and the borough records 'give definite instances' of carving executed by various named families.[98] Ipswich, then, in the mid-fifteenth century was a centre of the wood-carving industry, and a ready resource to which east-Suffolk carpenters could turn for the ornamentation of their hammer-beam roofs. Fully modelled angel hammer beams in the manner of Westminster Hall may have been monumental in effect, but in the interests of economy and efficiency, and

[93] Aston (2003), 68. Margaret Aston, *England's Iconoclasts*, Vol. I (Oxford: Oxford University Press, 1988) 20-22.
[94] Duffy, 38, 155.
[95] Aston (1993), 263; Duffy, 435.
[96] V. B. Redstone, *Ipswich Borough (Corporation) Records* (Ipswich: 1926-39), pt. 7, 1.
[97] V. B. Redstone, pt. 9, 5, 7.
[98] Armor, 208; V. B. Redstone, pt. 9, 5.

multiplicity of effect, smaller applied figures, probably mass-produced in the workshops of Ipswich and Norwich, became the more widely used. The carpenters as Debenham and Bardwell were early adopters of this streamlined production process.

In one crucial respect, however, later hammer-beam carpentry did follow the example of Westminster Hall. For Herland, form, ornament and illusion, the product of carpentered superfluity, outweighed mere constructional function. The deific Richard II must have been delighted at the way Herland’s receding trefoils created a tabernacled, niche-like space at the high end of his new hall, attracting the eyes of his subjects and framing the monarch in angelic glory. As we have seen on a lesser scale, Norfolk carpenters were interested in drawing the eyes of the parishioners forward to the devotional cynosures in the naves of their parish churches. East Anglian carpenters were to adopt, if not his carpentry techniques, then Herland's ethos that form, ornament and illusion should preside over structure.

If such concerns led to an increase in framing and conversion difficulties, then so be it. The hammer beam roof at Great Cressingham (Fig. 8.45) is ostensibly a standard example of the collarless Norfolk roof already discussed – albeit with some idiosyncratic figure carving. Yet with scrutiny one discovers the work of a cunning carpenter with a penchant for illusion and blasé about increased labour - provided there was an ornamental return. For example, the hammer post construction appears to the conventional arrangement of two discrete timbers: a hammer post and an arch-brace to principal, and this was the way the carpenter intended it to be apprehended (Fig. 8.46). It misled the contributor to the Pevsner volume who described the roof as having: ‘simple arch braces.’ Yet in reality, the hammer post and arch brace are one timber. To perpetrate the ruse, the carpenter worked a vertical roll moulding at the interface of the ‘two’ timbers. This roll moulding continues on to the principal, which is no conventional, straight, timber, but a component the carpenter took the trouble to shape in order to receive the hammer post and the illusory apex framing.

For the upper framing continues the theme of illusion. We finally discover an early Norfolk hammer-beam perhaps with a collar, albeit placed so high that any of its conventional function is nullified (Fig. 8.47). Yet this configuration, too, is carpentered *tromp l'oeil*. The principal rafter, as at Ely and Beeston, is flared in its upper reaches, but the Cressingham carpenter departed from conventional king pendant design – not, however, by incorporating a short collar. The collar is fictive. Rather he inserted – the taxonomy here is uncertain – what I propose to call a 'chevron yoke' at the apex of the principals. This anomalously shaped timber appears to have a very short pendant framed into it to expedite the framing of the principals and a braced ridge piece. Nonetheless, the carpenter has managed to present this framing as simply a short arch-braced collar. How did he achieve this? The roll moulding is again crucial to the artifice. The moulding runs out of the hammer post and into the principal where it continues until just before the apex, where the carpenter worked an obtuse-angled turn. He then cut the moulding along the 'yoke' to meet its counterpart in the opposite principal. The moulding now resembles the underside of a collar, and, to complete the illusion, the carpenter simply nailed on an embattled strip between the principals.

The flow of the roll moulding throughout the upper framing is executed with exceptional skill. In order to allow the profile to flow smoothly from one component to another, the carpenter had to cut a series of tedious tiny cross-grain mouldings. These so-called 'masons' mitres were probably all initially worked with chisel and gouge, and finished with a scratch-stock.[99] The shape of the principal itself is no less an example of superlative craftsmanship (Fig. 8.48). No structural need demands the principal to be crafted thus, but extra time and energy were expended fashioning its shape to the end of form and illusion. Indeed, the framing of the Great Cressingham roof is a bravura performance. As at Lynn and Bury, parishioners would have been oblivious to details known only to the carpenter at installation, and to visitors today equipped with binoculars. This was a carpenter profligate with his skills, blithe to additional labour, delighting in hoodwinking the viewer.

Such prodigality with skill and labour is also evinced by the inclusion by two carpenters in the early roofs of Table 8.1 of hammer beams in aisle roofs. No structural

[99] For 'scratch-stock' see Glossary.

justification exists for the insertion of hammer beams in lean-to roofs. Nevertheless, the patrons at Mildenhall and Beeston evidently wanted their north aisles to function as vehicles for devotional ornament, and hammer-beam carpentry was particularly suited to meet those desires. Mildenhall's superabundance of carving is particularly splendid, and of the most exquisite quality (Fig. 8.49). As at Bury, carpentry serves as ground for carving.

CONCLUDING REMARKS

In order to avoid repetition, in addition to remarking on Chapter 8 here, I will also draw together strands from the whole thesis.

Throughout this thesis we have witnessed the carpenter to be an innovative and creative craftsmen, whose finest work in the later Middle Ages must surely attain the status of art. We have seen the fourteenth-century hammer-beam roof, shackled to post-and-beam aisled construction, stillborn and abandoned for other, less advanced roof carpentry. It took the technical and aesthetic genius of Hugh Herland, driven by the demands of a demi-god, to unveil the true potential of the hammer-beam roof via an adaption of post-and-beam carpentry. Thereafter, the hammer-beam's roots in aisled construction were left behind, and the roof's full potential was realized with its application to bayed, principal-rafter carpentry, mainly in the churches of East Anglia. Rather, therefore, than thinking about notions of 'true' or 'false', it is evident that the hammer-beam roof developed from two discrete structural nodes. One, a structural solution, became a cramped developmental cul-de-sac; the other, of more formal and ornamental intent, became a broad avenue of varied forms.

The phenomenal blossoming of hammer-beam construction following Westminster Hall was no less than a revolution in roof carpentry. Indeed, as evidenced generally by my typology in Chapter 8, and in particular by later structures such as Tostock and Eltham, the later Middle Ages witnessed an astonishing turnaround in carpenters' priorities: from rational, prosaic, somewhat over-engineered carpentry, to the triumph of form and ornament. Westminster Hall, however, remained unique in structure, a masterpiece never replicated by medieval carpenters. Rather than a model to be slavishly copied, Westminster Hall's key function was to stimulate a re-evaluation of the aesthetic potential of carpentry. Its influence lay in its unprecedented form, ornament and illusion, attributes from which future patrons selected as they embarked on their church-building campaigns. They saw that the motifs of this secular hall, the receding arcuated forms, the angel-hammer beams, could be interpreted, adapted and applied with greater potency to an ecclesiastical space. Thus, angel-hammer beams suddenly appeared in church roofs regardless of structural need. In its turn, the structural hammer-beam roof became a theme upon which innovative craftsmen improvised. Norfolk carpenters adapted structure primarily in the pursuit of form; Suffolk carpenters in the pursuit of ornament. As the fifteenth century unfolded, cunning craftsmen, displaying themselves no mere banausic workmen, developed a discriminating aesthetic acumen and a taste for illusion. Structure, though seldom neglected, became secondary, and although developing divergent structural traditions, East Anglian carpenters maintained a common principal objective: visual delight in the service of ritual and salvation. Herland's objectives were almost identical, it was just that the 'salvation' was personal to Richard II.

Appendix 1

Checklist for the Survey of Hammer-beam Roofs, completed example:

BUILDING:	**BEESTON, Norf., St Mary. HB/HB**
SPAN:	22' 11' / 7M
PITCH:	SHALLOW - JUST
BAYS:	4/8 - match windows
W POSTS:	Yes; long; saints under nodding ogee canopies
CORBELS:	Yes
WALL PLT / C'NICE	Yes, modest; longitudinally braced
H BEAMS:	Main: short, brattished; Ints: RFHB, faces remvd
H POSTS:	yes; not on intermediate frames
K. POSTS:	no
COLLAR:	no
WIND Bs:	no
PURLINS:	2 Per Side
BOSSES:	yes, foliate
PLUMB?	No
ANGELS / CARVING	Exquisite
BUTTRESSES / M'NRY	Aisled
COMMENTS:	P. rafters appear to be shaped at top as at G. Cressingham

APPENDIX 2

THE ROOF OF WILLIAM II'S GREAT HALL AT WESTMINSTER: AISLED OR CLEAR SPAN?

I cannot agree with Christopher Wilson's arguments that the roof of William Rufus's hall was of clear span construction.[1] The features of the north elevation which he claims preclude aisled construction are not as he states 'known', and any reconstructions must be conjectural.[2]

Wilson suggests that the void of Rufus's hall was bridged by a tie-beam roof, but such construction would have introduced major problems of timber supply. A tie-beam roof would have needed beams of around 75ft (22.86m) in length in order to rest with any stability on the longitudinal walls. The longest known timbers used in any British medieval building are the posts in the lantern at Ely Cathedral (*c.* 1334) measuring an exceptional 62ft (18.90m). Trees of adequate size to provide the Ely timbers were rare, and documented as being 'sought far and wide, found with much difficulty, bought at a great price.'[3] Similarly, in the first half of the twelfth century, Abbot Suger found the sourcing of large beams to complete the Abbey of St Denis, Paris, by no means an exceptionally large building, almost impossible. Enquiries to local carpenters and foresters were met with bemusement: 'At this they smiled, or rather would have laughed at us had they dared; they wondered whether we were quite ignorant of the fact that nothing of the kind could be found in the entire region.' After a long search it was only divine providence that allowed Suger's carpenters to find the trees reserved for them by 'Lord Jesus.'[4] Added to this evidence is the Portfolio of Villard de Honnecourt, which documents a limited number of carpentry techniques of the first decades of the thirteenth century. Villard gives a number of examples of how large structures may be completed by carpentering together the compromise of short timbers, including a floor and a bridge.[5] Such advice indicates that longer timbers were not always readily available.[6] Interesting in this respect is a truss in the tie-beam roof of the south transept,

---

[1] Wilson (1997), p. 43 and nt. 46.
[2] Thomas, Cowie & Sidell, (2006), pp. 49-51.
[3] Salzman, 390; See Charles (1995) 47-49, for the sizes of trees needed for converted timbers.
[4] Holt, Vol. I (1981), 40-1.
[5] Folio 20r & 23r.
[6] In Anjou in the eleventh century the lords forbade the removal of oak wood, which was deemed the most important specie in the forest, Bechmann (1990), 158; for the shortage of timber trees see also 134, 165, 175, 177, 184.

Cathedral of Notre Dame, Tournai, Belgium, 1142-1150d. The span is only around 40ft (12.2m), but the tie beam is scarfed and supported in the middle by a short post rising from the apex of the dome.[7]

England was not extensively wooded in the Middle Ages as was once thought, but the Domesday Book does show that the countryside had large areas of oak woodland, and the cultivation of woodlands was a key part of the later medieval economy.[8] Could not Rufus's carpenters have found huge tie beams in these managed woodlands? Account needs to be taken of the growing habits of oak and contemporary techniques of woodland management. Left to grow wild, the English oak, though massive, is often a stubby, twisted tree.[9] A supply of long, straight timbers can only be relied upon through the practice of careful woodmanship, which, at the time, involved creating woodlands of 'standards' and 'coppice.' The standards were the timber trees used for carpentry. The coppiced trees, used for a variety of purposes, created underwood which encouraged the standards to grow tall and straight.[10] Throughout the Middle Ages it was the practice to fell standards comparatively young, when they reached a girth of around 18in (457mm) and a height that would yield building timbers of around 20-30ft (6.1- 9.14m) long.[11] These dimensions were adequate for the majority of dwellings. In an age before power tools and motorised transportation, the woodman learned to grow, and the carpenter learned to use, trees no larger than were necessary. The massive timbers required for any tie-beams in Rufus's hall would have been aberrant in managed woods of the period – they would have been cut down many decades previously when much smaller.[12] Hence, when in 1251 the monks of St Albans needed thirty unusually large oaks for building work on the abbey, nothing was available locally, and they had to be sourced from Henry III's woods near Carlisle – over 250 miles away.[13]

To sustain his argument in favour of tie beams, Wilson's asserts that arcade posts 'had they ever existed, would have been more substantial and almost as long as any tie-beams in the 11th century roof', thus implying that timber supply problems would have been just as acute in an arcaded structure. This contention, however, is unconvincing. Assuming Rufus's hall had both the same steep pitch of Herland's roof and his perfect

[7] Illustrated in Hoffsummer (2009), 166.
[8] 'England in the eleventh century would not have looked like modern Borneo, but rather like modern France', Rackham (2001), 53, also 44, 48-56; also Rackham (2003), 113, 126-7, 133.
[9] Rackham (2001), 43, 67, 68; Penistan, (1974), 102, 105-106, 109.
[10] For medieval woodland management see Rackham (2001), 63, 66-70; Rackham (2003), 182-5; Charles (1995), 47.
[11] Rackham (2003), 145-7.
[12] Rackham (2001), 66-74.
[13] Rackham (2003), 153.

1:2:1 ratio of nave and aisles (other halls had proportionally narrower aisles meaning shorter arcade posts), such posts would have been around 57ft (17.37m) long – about 25% shorter than any tie beams. Regarding the 'substantial' section of tie beams, such beams in English hall framing of the period, for example the Knight's Templar Hall at Temple Balsall, West Midlands, *c.* 1200d, and the Bishop's Palace, Hereford (1179d), appear to be of similar section to the arcade posts.[14] Moreover, structural design may have further shortened Rufus's arcade posts. Sir Frank Baines, following his survey of the roof in 1913-14, concluded that the posts were divided. A drawing executed at the time depicted posts which do not extend to the arcade plate, but terminate at wall plate level (Fig. A.1 below). At this point they are interrupted by a heavy-section aisle tie, upon which stands another short post which continues to the arcade plate. Also, Westminster Hall, standing on the banks of a then un-engineered Thames, was prone to frequent flooding. Matthew Paris wrote that during flooding in 1237 it was possible to row a boat in the hall, and of the floods of 1242 he commented 'none might get into Westminster Hall, except they were set on horseback.'[15] To prevent rot, it would be logical to place the feet of the posts on stone pedestals, as is the practice in many aisled barns – a refinement which would shorten the posts.[16]

The difficulty of finding beams of adequate *length* has been discussed, but it should also be adduced that any tie beams would correspondingly have to be of unfeasibly massive section, not only to support any surmounting timbers, but also the beams' own self-weight. Writing in 1903 on king-post trusses, the carpenter George Ellis remarked that 'It is not economical to employ this truss for greater spans than 32ft [9.75m] … if this span is exceeded, the tie-beam requires to be made of so great a depth to obtain sufficient stiffness … that it is difficult to obtain suitable scantlings.'[17] In the truss Ellis is describing, the king post is understood to be in tension, *supporting* the tie beam. Yet the English medieval carpenter had not yet conceived of such trussed construction. His tie beams were almost invariably *supportive* rather than *supported.* Thus, at Westminster, the tie-beams would necessarily be of even larger – impossible – section than those of Ellis's specifications.

Perhaps, however, in proposing huge tie beams, Wilson, is thinking of the hidden tie beams used over the vaulted naves of medieval French cathedrals and churches, beams which often are of surprisingly slender dimensions. During the twelfth century,

[14] See Walker (2011), 69.
[15] Quoted in Saunders (1951), 37; see also Gerhold (1999), 62.
[16] Horn & Born (1965), 68.
[17] Ellis (1927), 74, also 333. See also Benson (1995), 197-201; Sobon & Schroeder (1984), 90.

northern European carpenters did indeed begin to understand that tie beams, rather than *supporting* any surmounting timbers, could instead be *suspended* from tensional timbers – 'hanger' king posts and queen struts – and thus be of lighter scantling. But of the known twelfth-century examples the maximum span appears to be around 36ft (10.97m), and any wider buildings had some form of internal support.[18] The span of later structures employing these '*suspentes*', including the great French Cathedrals, is still modest compared to that of Westminster Hall. The nave of Notre Dame Paris, for example, is only around 42ft (13m).[19] In any case, the builders of some continental cathedrals and churches evidently put little faith in the security of this construction, and where possible they found means of supporting the tie-beam at its mid-point on the crown of the vaulting.[20] One of the few English examples that shows carpenters were groping towards this understanding is the nave roof of the Church of St Mary, Kempley, Gloucestershire (*c.* 1130d), where vertical struts with lap dovetails (hence the carpenter was thinking of the struts being in tension) suspend a low collar. The roof of moderate span at Kempley Church, however, is a rare example of this technique, and continental practice seems to have had little influence on English carpentry.[21] The overwhelming majority of tie beams in English medieval roofs are of proportionally heavy section and are often cambered, indicating, as noted earlier, that the English carpenter understood the tie beam to be, not a suspended, but a supporting timber.

Wilson's statement: ''Westminster Hall could have been achieved by means of collars or tie beams formed of more than one piece of oak' is conjectural. No evidence exists that that that eleventh-century carpenters had developed the sophisticated scarfing and/or laminating techniques essential for such construction.[22] Indeed, current archaeological opinion is that carpentry techniques in Britain remained fairly rudimentary until around the middle of the twelfth century.[23]

Further, through to the end of the fourteenth century, perhaps vicariously exploiting the divine associations of ecclesiastical architecture, it seems to have been the norm for most great halls to be aisled, both for fashionable and functional reasons.[24] The

---

[18] Épaud (2007), 139, 163-164, 167-169.
[19] Hoffsummer (2009), 184.
[20] Hoffsummer (2009), 174, 180, 182.
[21] Walker (2011), 67
[22] *EHC*, 35-58, 263-271; Hoffsummer (2009), 59; Épaud (2007), 177; Milne (1992), 18-19.
[23] Personal communication with Dr Damian Goodburn of the Museum of London, 21/09/2012. Dr Goodburn believes that even the later medieval carpenter's 'bread and butter' joint, the mortice and tenon, appears not to have been in common use before this time. I perhaps should add that I do not concur with Dr Goodburn's view that carpentry practice before *c.* 1150 was necessarily crude.
[24] Thompson (1995), 26-27, 103-105.

builders of halls even of modest span, where masonry walls could have been built up or taller wall framing employed for a tie beam then to be inserted, often still preferred aisled construction.[25] Would there have been such a proliferation of aisled seigneurial halls if the bench-mark of the high-status hall, in the royal palace at Westminster, had been of open-span construction? Surely, lesser magnates would follow an architectural trend established in the very highest echelons of society. Further, from a visual viewpoint, tie-beams would also have provided a monotonous internal aspect devoid of loftiness. Presumably, to a patron as demanding as Rufus, such a lowering, ponderous vista would have been unacceptable.

To précis, therefore, there is little to suggest that eleventh-century carpenters had either the timber or the technology to construct a massive tie-beam roof required by the Westminster span. The locating, conversion, framing, transportation and erection of such massive timbers seems highly unlikely and is untypical of any known English and northern European carpentry both in the eleventh century and throughout the later Middle Ages.[26]

Eric Fernie in *The Architecture of Norman England* (2000) offers little comment on the nature of the great hall's original roof, but his remarks on how the carpenter may have accommodated the errors of the mason incidentally offer cogent evidence that the roof was of aisled construction.[27] The bays as built by the Norman masons are misaligned, that is, by a distance of some four feet, they are not orthogonal to each other (see Fig. 5.5). This error is odd, especially as the terminations of the north and south walls appear to be aligned. Explanations range from the need to create a new building around an existing un-demolished hall, to masonic incompetence.[28] Contemporary Norman buildings of highly competent construction gainsay the latter argument, and surely it was not beyond the wit of the mason to design a simple template to accurately lay out the bays, probably a tagged or knotted rope, or possibly a 'story pole' (a length of timber with notches) corresponding to the major divisions of a structure, irrespective of any existing

[25] Walker (2011), 14, 69; Roberts (2003), 5.

[26] Medieval roofs of wider span existed in southern Europe, for example in Padua, the Pallazzo della Ragione of the early fourteenth century with a span of around 90ft (27.5m). Such roofs, however, were the product of a differing carpentry (indeed, engineering) tradition. Firstly, they utilised pine, which, as anyone who has taken a walk in both a pine forest and an oak woodland will know, is naturally available in straighter and longer lengths than oak (see Penistan (1974), 98-111). Secondly, the tie-beam trusses at Padua only function because they formed of composite timbers, are bound together by an assortment of ironmongery. See also Wilson (1997), 55, nt. 98.

[27] p. 85.

[28] *HKW*, 47.

building. Nonetheless, such a gross error, for a patron as uncompromising as William Rufus, may have had mortal consequences for the builders. And here it is worth taking a moment to consider the character of William II and his amenability to error committed by those in his service.

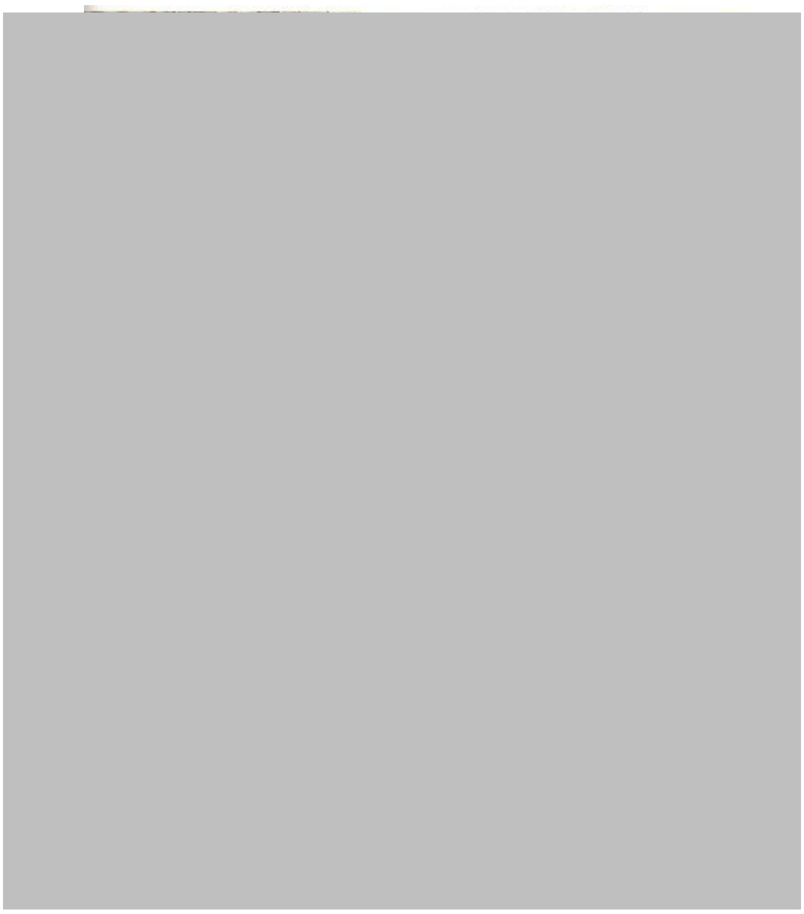
According to the chronicler William of Malmsbury, Rufus was 'a martinet', who towards the end of his reign became increasingly irascible. 'His high-mindedness [became] pride, his strictness cruelty', and 'the heat of viciousness boiled up within him.'[29] Accused of treachery, William of Eu, experienced that 'viciousness' intimately. 'Being sluggish in justifying himself [he] was deprived of his eyes and testicles.'[30] Shortly after documenting William II's death, the chronicler Roger of Wendover devoted a page to the character the 'martinet' king. It was no eulogy. Rufus 'was cut off in the midst of his injustice.' He 'was a tyrant of his own people' who 'always did whatever evil was in his power … a wicked king, hateful to both God and man … England could not take a breath under the burdens which he laid upon it.' 'The King and his servants laid violent hands on everything, creating confusion and destruction on all sides', and 'his tomb was watered by no one's tears, so great was the joy which the people felt at his departure.'[31] It is significant that, by contrast, after reporting the deaths of Rufus's royal predecessor and successor, Roger offers little comment. Rufus's cruelty must have been uncommonly extreme for Roger to be moved to write such an excoriating obituary. Rufus also seems to have had a streak of vanity which demanded the very best in material accoutrements. Barlow calls him a 'dandy.'[32] Informed one day that his new shoes cost only three shillings, he exploded into rage, demanding of his valet: 'since when has the king worn such trumpery of shoes?' The valet was sent out to buy a more expensive pair.[33] So it is only natural that Rufus, in constructing his new palace at Westminster, 'spar[ed] no expense to secure an effect of open-handed splendour.'[34] Rufus, therefore, demanded the best, and he displayed it.

Brutality blended with a pernickety vanity and a penchant for ostentatious display is a deadly combination for anyone engaged in royal works. The builders of

[29] Malmsbury, trans. R. A. B. Mynors (1998), 312. Many monastic chroniclers were biased against William because he appropriated church funds, so their accounts may be suspect. William of Malmsbury, however, worked directly for Rufus's family, and copies of his chronicles were given to them in the early twelfth century. Malmsbury 'was obliged to omit a good deal of the criticism that he felt about King William II, and instead to comment favourably upon him', Mason (2005), 14. Any negative comment must, therefore, be given some credence.
[30] Malmsbury, 319; also Mason (2005), 164.
[31] Wendover, trans. J. A. Giles, Vol. I, pt. 2, 1066 - 1170 A.D. (1994), 445-6; also Barlow (1983), 28, 99-100
[32] p. 99.
[33] Malmsbury, 313.
[34] Malmsbury, 321.

Westminster Hall must have done all in their power to attenuate their clanger of misaligned walls. A solution would have been to employ a time-honoured builders' technique when discovering a blunder: hide it or disguise it. The former was impossible. Disguise, on the other hand, was feasible – by constructing an aisled structure. By placing the arcade posts orthogonally to each other and to the divisions of *one* longitudinal wall, Rufus, seated on the dais at the south end of the central vessel, would have seen a rhythm of main lateral roof timbers presented in perfectly aligned order. The error could then have been accommodated by connecting the aisle ties with the misaligned masonry bay divisions of the other wall. Here, the distortion would have been less noticeable. By contrast, a series of tie-beams spanning the entire width of the hall would only have served to accentuate the misalignment. One can imagine the fury of William Rufus on entering his new hall and seeing not 'open-handed splendour' but a distorted vista – not to mention the scrotum-tightening dread of the builders. An arcaded structure of nave and aisles would have been their saviour.

Fig. A.1: Reconstruction drawing of William II's great hall at Westminster, office of Sir Frank Baines, HM Office of Works, *c*. 1914. (National Archives)



APPENDIX: 3

EVIDENCE FOR DATES OF EARLY FIFTEENTH-CENTURY HAMMER-BEAM ROOFS IN TABLE 8.1

DEBENHAM CHURCH, Suffolk: 1403 ± 6

Tree-ring, *VA,* Vol. 32, p. 73.

ST GILES, NORWICH: probably early fifteenth-century.

St Giles is asserted in all secondary literature, from Francis Blomefield, 'the whole was rebuilt in Richard II's time', to the church website in 2013, to belong to the late fourteenth century or the very early fifteenth century.[1] Frustratingly, none of these accounts supply any evidence for their ascriptions. Nonetheless, St Giles was once the property of Norwich Cathedral, so one is left to assume that for such a well-documented institution, the apodictic date given by the secondary sources for one of the cathedral's satellite churches must be correct, no matter how parsimonious their citations. Circumstantial primary evidence does exist: bequests for building works were made in the late fourteenth and early fifteenth centuries, including one in 1386 of 30 shillings by Stephen de Holt;[2] a hammer-beam angel bears the arms of Henry IV; and building works are known to have been taking place in the early fifteenth century, including the completion of a new tower.[3]

Concurring with that of F. E. Howard and Mortlock & Roberts, my own view is that the roof dates to around 1414. Fires of 1412 and 1413 destroyed many of the city's buildings. Blomefield writes that in1413: 'A great part of the city had the misfortune to

[1] Blomefield (1805-1810), Vol. IV, 245; < www.achurchnearyou.com/norwich-st-giles > accessed 04.06.2014.

[2] Cattermole (1983), 258.

[3] Mortlock & Roberts (2007), 210; Cautley (1949) 225-6; < www.norwich-churches.org > accessed 02.04.2013.

be burnt down.' The Church of the Blackfriars, now St Andrew's Hall, was 'consumed.'[4] St Giles is half a mile away.

KING'S LYNN, CHAPEL OF ST NICHOLAS: *c.* 1400-19

St Nicholas is described in an original document as *de novo edificato* in 1419, but as James & Begley point out, the building was probably completed some years before then.[5] A papal bull had been issued in the 1370s for the rebuilding of the chapel. In the early nineteenth century, Blomefield recorded a window (now lost) by the north door with the date 1413 inscribed.[6] In 1399, a citizen of Norwich, John Wace, gave instructions that his body be buried in 'the entrance before the great door of [St Nicholas] towards the west.' All these indications lead to the conclusion that the chapel was rebuilt sometime between 1380 and 1413, with the roof obviously being one of the last structural components to be completed. Early nineteenth-century illustrations show the roof much as it is today, so apparently it has suffered little from seventeenth-century iconoclasts and the nineteenth-century restorers.[7]

GREAT SHELFORD, CAMBRIDGSHIRE, ST MARY: *c.* 1400-1411

All secondary sources, *VCH*; Doyle (1961); Cotton (1997); *NHLE*, agree that the church was virtually rebuilt by Thomas Patesley, Archdeacon of Ely and rector at Great Shelford, from 1396–1411/18.[8] Clerestory detailing is also indicative of such a date. The window tracery is similar to, and thus possibly contemporary with, that at Balsham Church, 10 miles away, built before 1401 by John de Sleford (d. 1401). His brass in the chancel proclaims '*ecclessiam struxit*.'[9]

[4] Blomefield (1745), 92; 'A greater part of the city was burnt down', in Anon., *A Compleat History of the Famous City of Norwich …* (London 1728), 26; See also Anon., *The History of the City and County of Norwich, from the Earliest Accounts to the Present Time* (Norwich: John Crouse, 1768), 107.

[5] James & Begley (2000), 4-5.

[6] Blomefield (1805-1810), Vol. VIII, 511, 512; Cattermole (1983), 253.

[7] James & Begley, 11.

[8] The completion date of his rectorship seems uncertain.

[9] Cotton (1997), 97.

WESTERFIELD, SUFFOLK, ST MARY MAGDELENE: possibly *c.* 1400

Primary information on this church seems non-existent and secondary sources are scant.[10] Indeed, the only documentary reasons for including this structure in the table of early post-Westminster Hall hammer-beams is a tantalising reference in *NHLE*: 'The church was refurbished in *c* 1400, when the hammer-beam roof was constructed', and a comment in the 1980 Church Guidebook by Roy Tricker that the roof was constructed in the 'early years of the fifteenth century.'[11] The church seems to have undergone few major alterations since its late thirteenth, early fourteenth-century construction. The fifteenth-century mania for aisle and clerestory building passed Westerfield by, and, apart from the tower, alterations seem to be limited to modifications to doorways and windows. The roof, then, is not contemporary with any Perpendicular clerestory as is the case with many hammer-beam roofs. Major fifteenth-century building works did take place, with the construction of the tower, and secondary sources date the tower to early in the fifteenth century. The roof could, therefore, be coeval with the tower. Further, the roof is of a fairly steep pitch, which may indicate an earlier rather than a later date. All, though, is vague and circumstantial.

The roof carpentry, however, may be interpreted as indicative of early construction. Westerfield's hammer-beam is atypical. Much of the hammer beam is redundant. The hammer-post is set well back from the end of the hammer beam, the final half serving merely as a fixing point for inclined angels and saints. The hammer post and their attendant arch-braces act virtually as one timber. Indeed the 'arch-braces' here have little of their normal bracing function, being almost vertical timbers, but flared out to meet the principal. The hammer braces also terminate midway along the hammer beam. The hammer posts, then, project beyond the internal plane of the walls by just a few inches, and may be seen as an ingressive ashlar pieces. Indeed, the carpenter of this roof, as though not trusting the new, relied on traditional technology to augment lateral stability, and went to the trouble of creating a huge rafter foot. Some sole pieces in the

[10] The churchwardens' accounts held by the Suffolk Record Office only begin in 1759.

[11] Tricker (1980), p. 5; Mortlock, Vol. 2 (1990), 222-3.

common rafter frames oversail both the external and internal wall surfaces. The carpenter evidently knew and trusted the stability of the rafter foot, and, lacking the confidence to frame the hammer posts into the extremities of the hammer beams, in this un-tied roof took pains to make the foot as large as possible. Such construction connotes experimentation and *perhaps* an early date. Was this a hesitant and cautious carpenter, relying on generations-old tradition as he came to terms with the new hammer-beam technology?

BEESTON-NEXT-MILEHAM CHURCH, NORFOLK, ST MARY: probably *c.* 1410.

Dendrochronology, alas, failed at Beeston. The dating rests on one piece of primary documentary evidence uncovered by Francis Blomefield: a bequest of 1410 for the glazing of the clerestory.[12] Such a bequest indicates that the heightening of the nave walls was well underway at that time, or was an imminent priority. Further, it is unlikely that glaziers would have been at work below, installing their delicate and expensive medium, while carpenters were at work above, manoeuvring massive timbers and swinging hammers. Thus, subsequent sources concur that the hammer-beam roof at Beeston was completed around this time. Cautley even thought that the nave arcades and clerestory were of 'one build', although the differing strata of the clerestory masonry cast doubt on that claim.

WINGFIELD, SUFFOLK, ST ANDREW: *c.* 1415

Held by The Bodleian Library, Oxford, Wingfield is one of few medieval churches for which a building contract exists.[13] A note included with the manuscript, states '? Early 15th century, before 1450 [? C 1430].' The question marks are telling, as the date of the contract has subsequently been disputed. J. H. Harvey (who possibly wrote the note on the manuscript) and Birkin Haward both dated the contract to around 1430, whereas after more recent research, John Goodall dated it to the 1460s.[14] The *exact* date of the

[12] Blomefield (1805-1810), Vol. IX, p 465. Pevsner, *Norfolk* 2, 201.

[13] The contract is reproduced in Haward (2000), 48; and Goodall (2001), 270-2.

[14] Birkin Haward, (1993), 376-7; *EMA*, 132; Goodall (2001), 269-70.

contract is, nonetheless, immaterial for the dating of the roof of the nave. The salient point is in the detail of the work for which Master Mason Hawes of Occold, Suffolk, was contracted. Hawes was commissioned to alter the chancel, and the Lady Chapel located to the south of the chancel. Both structures were to be lengthened; new windows were to be made, and existing ones reset. The existing nave was to receive little attention. Rather - and this is the key point - in addition to being lengthened, 'ye same Chauncell walles to be hyghed conveniently after ye heghte of ye Churche walles. And therynne to be made a clerestory with vj convenient wyndowes on eyther syde of ye chancel.' As this mid fifteenth-century chancel is today the same height of the nave, the 'churche walles' must mean the nave walls. Hawes, therefore, was contracted to raise the walls of the chancel to the same height of a pre-existing, clerestoried nave. The nave, its clerestory, and crucially its roof, must, then, belong to a building campaign/s earlier than *c.* 1430 (or *c.* 1460).

The building history of Wingfield Church, is difficult to unravel, but all authorities agree that two campaigns preceded that referred to in Hawes's contract: 1: the initial build following the death of its founder, Sir John Wingfield, in 1361, during which the main body of the church was completed;[15] 2: Alterations of *c.* 1415 during which the Lady Chapel was built, into which the tomb of Michael de la Pole was inserted. The clerestory and roof of the nave must, then, belong to one of those periods.[16] The windows of the nave clerestory, Perpendicular in style, differ from those in the south aisle, which are 'Decorated'. The aisle windows must therefore belong to build 1, of 1361 onwards. The nave clerestory windows also differ radically in style and number from their counterparts in the chancel, which we know from Hawes's contract to belong to build 3: post 1430. It seems likely, therefore, that the clerestory and its roof were raised in build 2, *c.* 1415, as part of other alterations to the church. The masonry of the clerestory is uniform, indicating one build and little subsequent alteration. A further piece of evidence is found in the nave clerestory windows. Of three lights with cinque-foiled

[15] The foundation charter of 1362 still survives at Norwich and Eton libraries, Richard Haslam, 'Wingfield College, Suffolk', *Country Life*, Vol. 171 (1982), Jan. 7, pp. 18-20
[16] The building works are discussed in detail in Goodall, 55-65.

heads and staggered transoms, they appear to be a refinement on the theme in the clerestory just thirteen miles away at Debenham, securely dated at 1403 ± 6d. The archaic construction of the Wingfield roof - common rafters, collars and soulaces – also connotes an early date.

BILDESTON, SUFFOLK, ST MARY: *c.* 1420

Although of a slightly steeper pitch, in form and structure the cambered tie-beam / hammer-beam roof of Bildeston is almost identical to that 18 miles away at Debenham, of certain date: 1403 ± 6d. That fact alone is not enough to categorise Bildeston as a 'probable' early hammer-beam, but here the work of Haward assists the dating process. Comparing the details of the masonry, particularly the sculptural embellishment of the nave arcading, Haward concluded that they were, 'clearly by the same master mason as… Debenham.'[17] Further, the clerestory windows are, as at Wingfield, a variation on the theme at Debenham. Minor primary evidence exists: in1420, John Hastyng bequeathed 20s for 'new work' to be done.[18]

BARDWELL, SUFFOLK, ST PETER & ST PAUL: *c.* 1421

The church was the gift of Sir William Berdewell (1367-1434). The arms of Sir William and his wife are in the spandrels of the arch over the south doorway, and he is depicted in original stained glass in the north-east wall of the nave.[19] One of the original hammer-beam angels holds a book on which the date 1421 is painted. Further, the windows of the aisle-less nave are more late-Decorated than Perpendicular in character.

[17] Haward (1993), 168.
[18] *Bildeston Church and Village* (Bildeston P.C.C., 1987), 7; Haward (1993), 168; Haward (2000), 18-19.
[19] Haward (2000), 15-17.

WIGGENHALL, NORFOLK, ST MARY MAGDALEN: 1420-35

Nave and aisles are of the same building campaign of *c.* 1420-1435.[20] Dendrochronology for the aisle roofs (1419±16) has confirmed this construction date. Tracery details also indicate a date from the first third of the fifteenth century.

ELY CATHEDRAL, N. & S. TRANSEPTS: 1426 – 27

Tree-ring. *VA*, Vol. 22, p. 40.

The samples were from the roof of the south transept. The north transept, of similar design, is presumed to be of the same date.

MILDENHALL, SUFFOLK, ST MARY: *c.* 1420-30

According to Alfred E. Simpson the highly ornate nave roof was made possible 'by the munificence of Sir Henry Barton' (d. 1435),[21] successful entrepreneur, Serjeant of the King's Wardrobe, member of the Commons, Sheriff and twice Lord Mayor of London.[22] Simpson calls Barton 'a native of Mildenhall', although his true connections with the town are unclear. Serious connections, though, there were. He had major property interests in Norfolk and Suffolk; he left a considerable sum to the poor of Mildenhall at his death; his memorial stands in the south aisle of the church, and the font bears his arms.[23] A wealthy purveyor of furs and pelts, skinner for the King's household, and one of the London's major property owners, Barton would certainly have had the funds to be a major donor for any works carried out at Mildenhall in the early fifteenth century – the period of the height of his financial success. Barton was even a credit broker to the Crown in the early decades of the century. All secondary sources from Cautley and Pevsner through to the current Church Guidebook, follow Simpson's line that, with Barton as the major benefactor, the nave and north aisle of St Mary's were reconstructed in the first few decades of the fifteenth century. Significantly, as a prominent figure in

[20] *NHLE*; Pevsner reports a will of 1432 towards rebuilding, *Norfolk* 2, 478.
[21] Simpson (1901).
[22] For a biography of Barton: Roskell *et al*. (1992), 135-138.
[23] Mortlock, Vol. 1 (1988), 153.

the London establishment, with connections to both the royal household and that of John of Gaunt, it seems unthinkable that Barton would not have been present at the public proceedings surrounding the deposition of Richard II in Westminster Hall.

GREAT CRESSINGHAM, NORFOLK, ST MICHAEL: *c.* 1430

Various bequests were made towards the reparation of the church from1415-31, including in 1415 the considerable sum of 100s donated by Richard Bolton.[24] Major works were, therefore, underway during this period. The clerestory windows also connote an early date, the mouchette forms harking back to the Decorated period.[25]

BURY ST EDMUNDS, SUFFOLK, ST MARY, *c.* 1430

St Mary's is placed with confidence by almost all secondary sources to 1424-33. Various, some quite large, sums of money were bequeathed to the 'fabric' and 'structure of the new Church of St Mary', during this period.[26] Tymms mentions the immense sum of £20, bequeathed in 1425 by the 'brasier' John Roche, towards the construction of the new church.[27] Bequests were made in 1434 for new benches, and in 1436 for a rood loft.[28] It is unlikely that such furnishings, especially an ornate rood loft, important both liturgically and decoratively, would have been constructed while the roof was still open to the weather and carpenters were wielding tools and manoeuvring heavy timbers above.

Caveats should be appended. J. B. L. Tolhurst in a brief paper in the *The British Archaeological Association Journal* of 1962 held the idiosyncratic opinion that the final, most eastern, pairs of angel hammer-beam figures were representations of Henry VI and his wife Margaret of Anjou.[29] This would obviously date the roof to after their marriage in 1445, which seems rather late in the light of the other evidence - and even the self-

[24] NA, 'Will of Richard Bolton of Great Cressingham, Norfolk', 1415, Prob 11/2B/41; Cattermole (1983), 244.
[25] Pevsner, *Norfolk* 2, 363. *NHLE*: 'clerestory windows in Decorated style with multi-cusped soufflets.'
[26] Paine (2000), unpaginated.
[27] Tymms, (1845-54), 19-20.
[28] Paine; Pevsner.
[29] Tolhurst (1962), 69-70.

deified Richard II was never represented as an angel. Other writers identify the final pair of figures as the Virgin Mary and the risen Christ.[30] Alternatively, the pair of figures immediately to the west of Mary may be representations of the angel Gabriel. As a figure associated with the Annunciation, it would be apt if he was immediately adjacent to Mary (rather than Margaret of Anjou).[31]

Gail McMurray Gibson thought the roof belonged to *c.* 1445 due to details in the will of Bury resident John Baret (1463) and a correspondence between the iconography of the roof and his own tomb.[32] She quotes Baret: 'all the work of the angels on loft for which I have do made for the remembrance of me and my friends.'[33] Baret's cryptic phrase has, however, been interpreted by other scholars – including the editor of the Bury wills and the authority on St Mary's, Samuel Tymms, as a bequest for the painting and gilding only of the angels directly above the rood loft, which still retain some of their paint.[34] Indeed, Baret's tomb originally stood in the nave below the most eastern pair of figures adjacent to the loft. On balance, taking into account the above primary and secondary sources, I remain with the majority view that the roof dates to around 1430.

---

[30] Sandford (1962), 12; Anon*.,* (1955), unpaginated; Tymms (1854-54), 170-1.

[31] Sandford (1962), 10.

[32] Gibson (1989), 170-3.

[33] Tymms (1850), 39.

[34] Tymms (1845-54): 'The principal at the end of the nave, which formerly sheltered the holy rood, [canopy of honour] was painted and gilded at the cost of John Baret, whose mottoes or 'resons' of 'God me gyde' and 'Grace me governe' are inscribed on the braces of the hammer-beams', 169

GLOSSARY

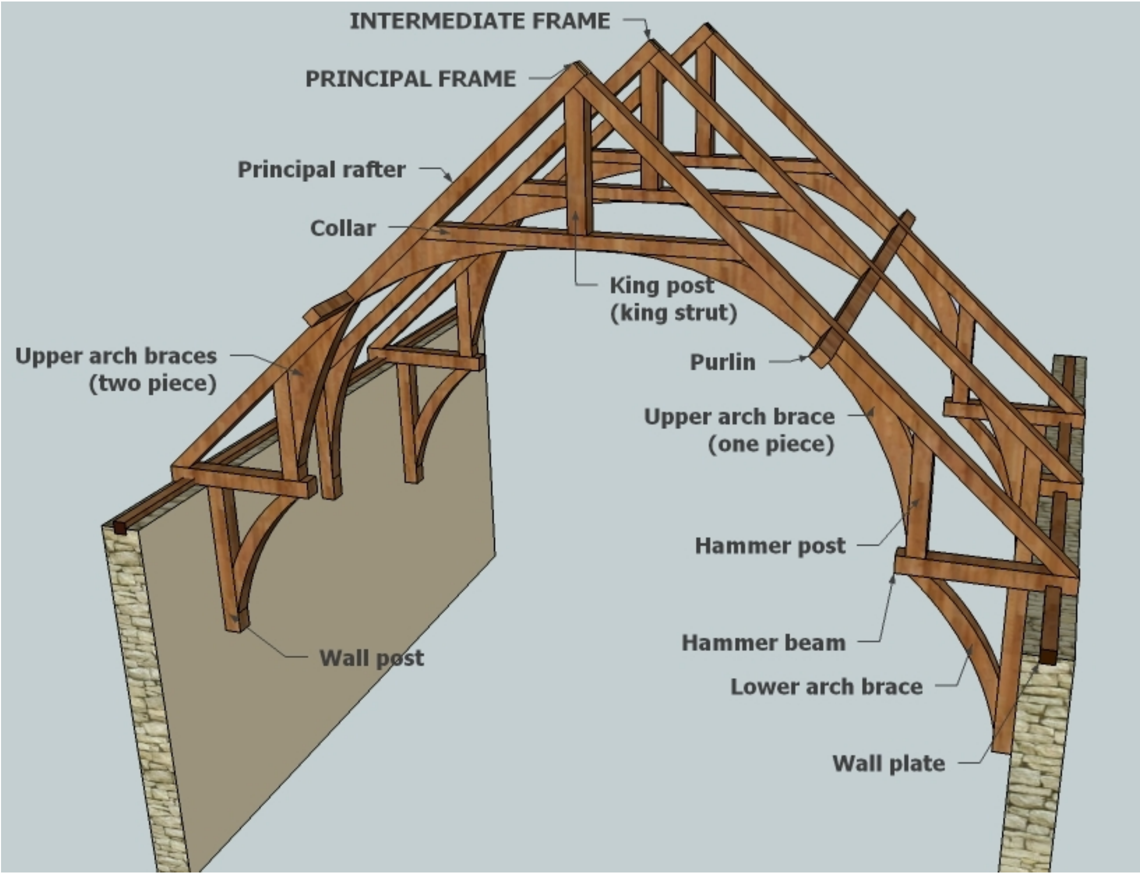


Fig. A: Main components of a generic hammer-beam roof

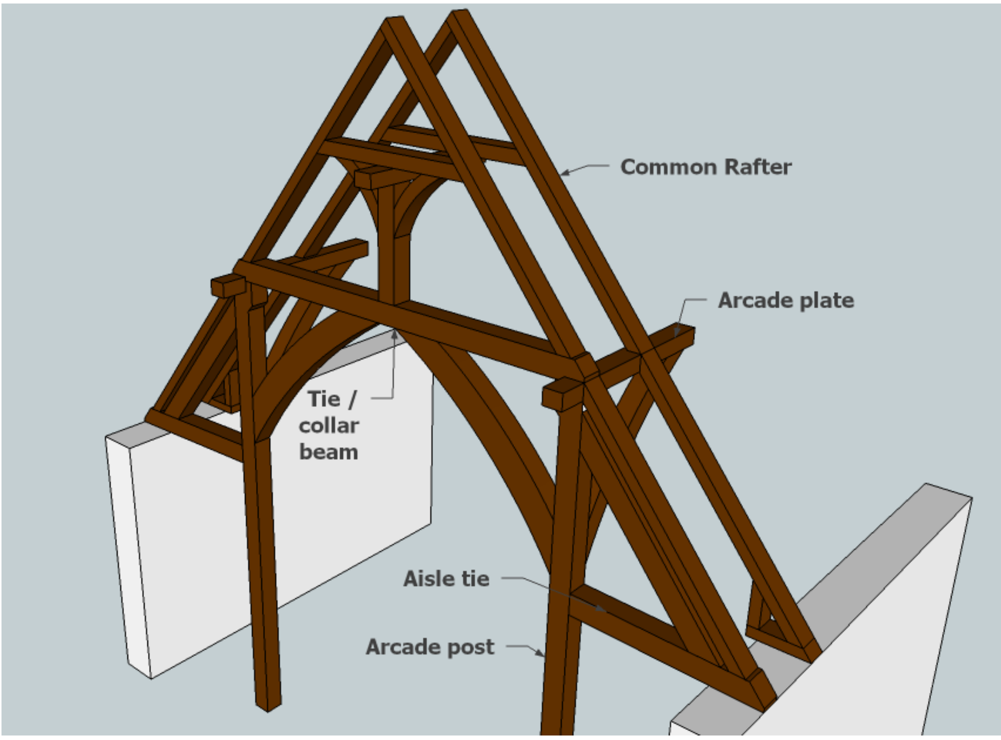


Fig. B: Generic Aisled Construction.

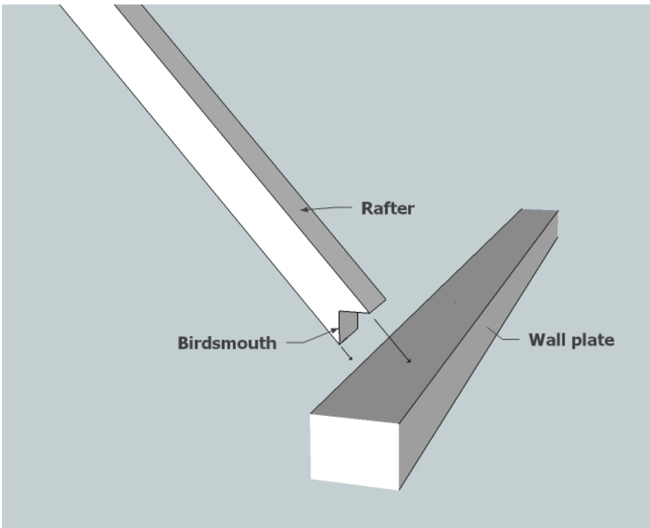
Aisle Tie: Transverse timber connecting wall plate with arcade post in an aisled structure (see Fig. B).

Arcade Plate: In aisled construction, longitudinal timber, square-set (to the ground), into which the tops of the arcade posts and the tie-beams are framed.

Arcade Post (aisle post): In aisled construction, vertical timber carrying arcade plate and tie-beams. Corresponds to masonry piers in the arcade of a masonry structure.

Ashlar Piece: Vertical timber at the rafter foot forming a triangle with the common rafter and the sole piece. See 'foot of rafter' below.

Birdsmouth Joint: Notch cut into the end of a timber to accommodate the arris of the timber to which it is framed. See below.



Birdsmouth Joint

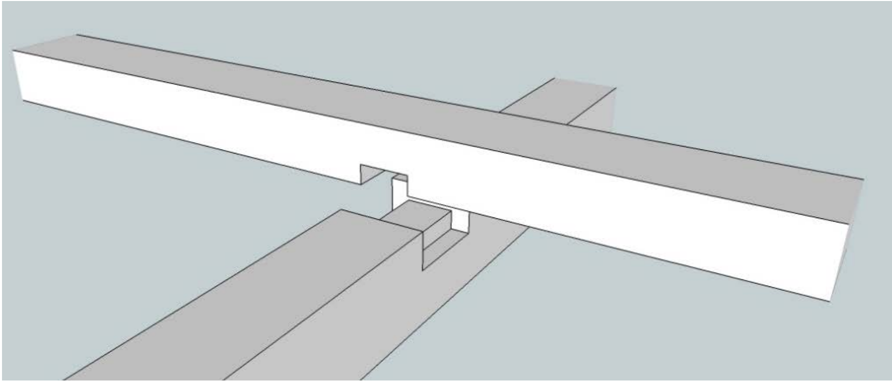
Brace: Timber usually set between vertical and horizontal members to provide triangulation.

Bridle Joint: The negative of a mortice and tenon joint. Solid timber replaces the mortice and two adjacent housings are cut; the tenon is absent but the tenon cheeks remain.

Butt Purlin: See 'purlin.'

Carpentry: Structural timber work, in contrast to 'joinery', which is concerned with ancillary components such as windows and door-frames.

Cogged Joint: Type of lap joint with a central raised section; see below:



Cogged Joint

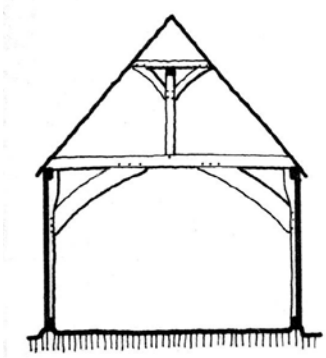
Collar: Horizontal, transverse timber connecting either ‘common’ or ‘principal’ rafters (see fig. A).

Common rafters: Inclined timbers of uniform scantling that directly support the roof covering.

Common rafter roof: Roof without principal rafters and purlins composed entirely of common rafters as inclined members.

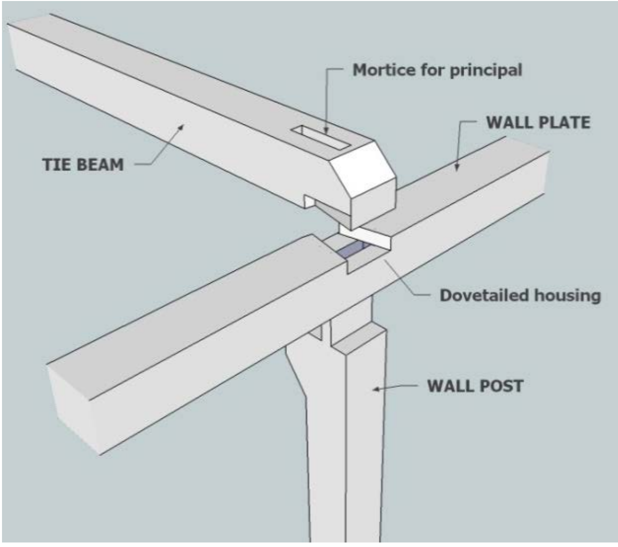
Conversion: The process of obtaining useable building timbers from a growing tree.

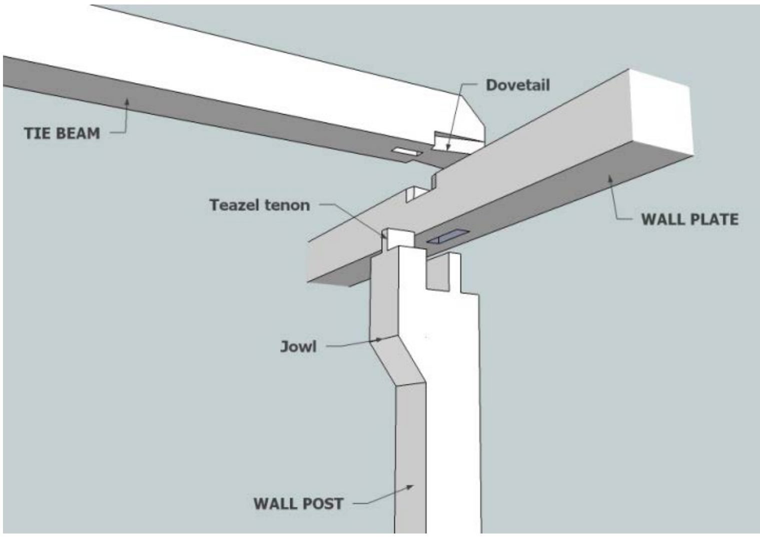
Crown-post roof: See illustration below. The central vertical timber is the crown post.



Draw Boring: A technique to ensure a tight fit of the shoulders of a mortice and tenon joint. The peg hole in the tenon is offset, towards the shoulder, with respect to the peg hole in the morticed timber. The offset ensures that once the peg is driven home, the joint is pulled together. The technique also serves to compensate to some extent for future shrinkage of green timber.

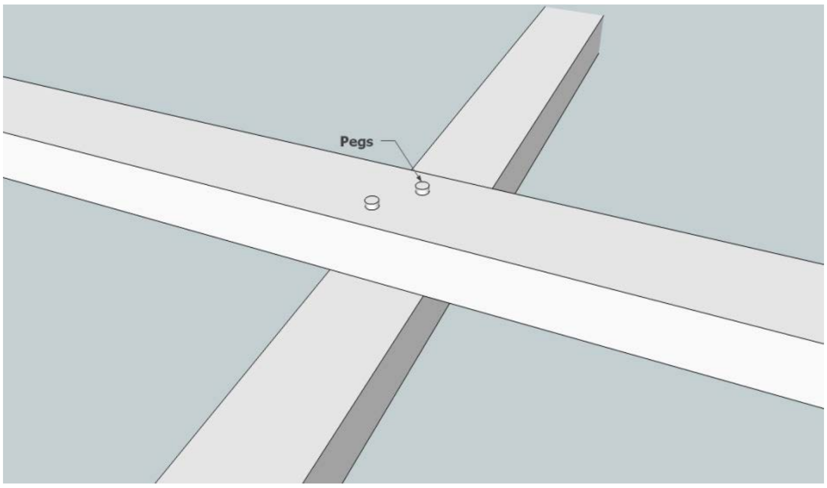
English Tying Joint (**normal assembly**): Four-way (with principal) configuration found at the top of a wall post. Commonly found in late medieval and post medieval framing. *Cf.* ‘reversed assembly’ below.





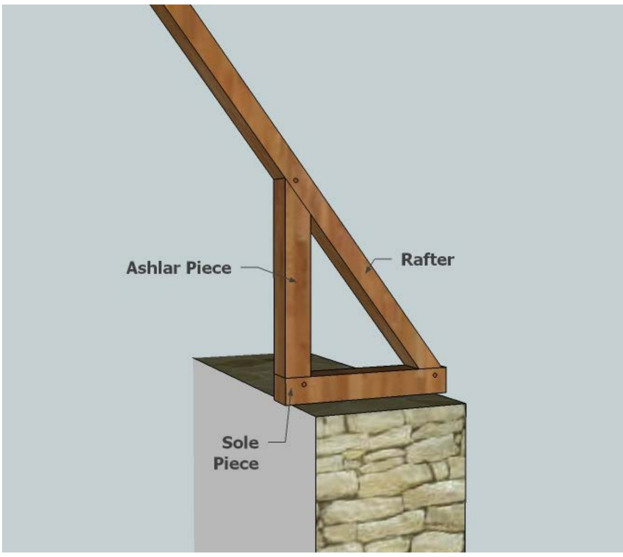
Generic English Tying Joint, from above (top) and below.

Face Pegging: Simple and relatively weak technique for joining overlapping timbers merely by pegging; see below:



Face-pegged joint. Note the timbers are not housed (*cf.* 'cogged joint').

Foot (of rafter): Configuration at the base of the rafter consisting of ashlar piece, sole piece, rafter; see below:



Rafter 'foot'.

Frame (verb): To construct; to carpenter (eg: 'the roof was framed in 1468'); to joint (eg: 'the hammer post was framed into the rafter…'). Such usage goes back many centuries (see Salzman, 579, for an example from 1532), and it is still common terminology among 'framers' (traditional carpenters) today.

Hammer Beam: Horizontal transverse timber projecting from the inner face of the wall, supports hammer post (see fig. A).

Hammer Beam Angel (HBA): Discrete carved figure applied (usually morticed) to the end of a hammer beam. Eg: Tilney All Saints, Norf., below. (cf. 'Recumbent-figure hammer beam').

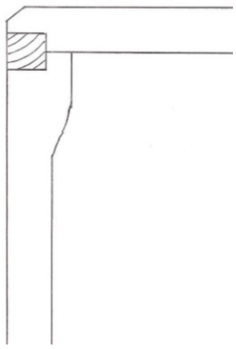
Three 'hammer beam angels' (HBAs). The figure at bottom left is an example of a 'recumbent figure hammer beam.'

Hammer Post: Vertical timber, rising from the end of the hammer beam (see fig. A).

Intermediate Frame: Transverse wooden framework of less structural / ornamental importance than principal frames (see below), often subdividing a bay (see fig. a).

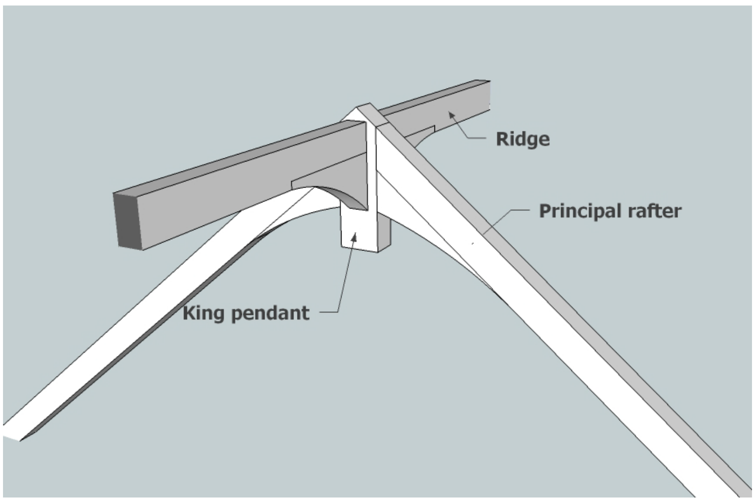
Joggle: Flared upper section of a timber, usually a king post. See illustration for 'King Post Roof' below.

Jowl: Flared section of post to accommodate joint(s). These were often converted from the lower section of the tree where the trunk expands to form the root bole.



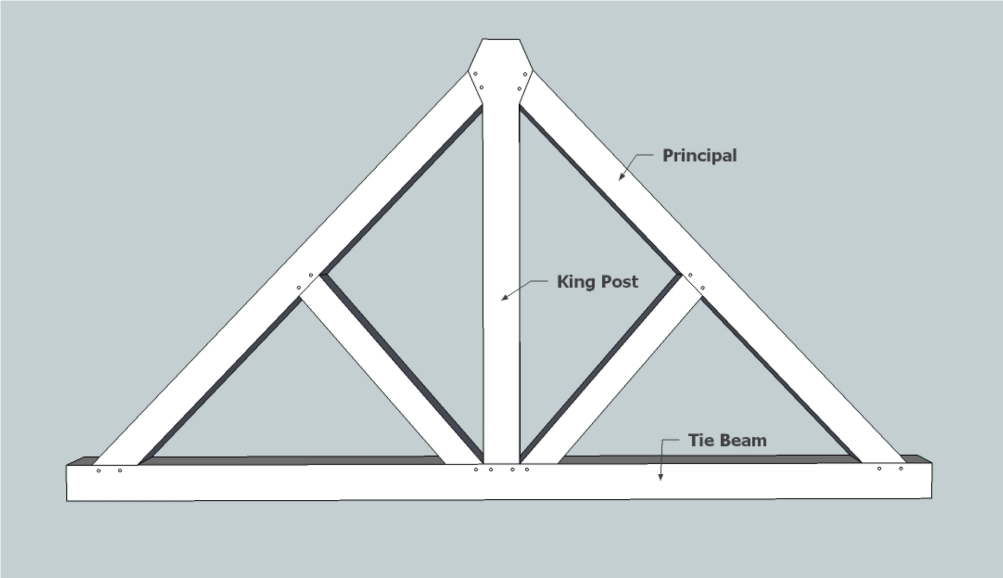
Jowl

King Pendant: (in hammer-beam and arch-braced roofs) Vertical timber descending from apex into which the principals are framed, and possibly ridge pieces; frequently found in Norfolk medieval roofs; see illustration below.



King-pendant consruction

King-Post Roof / Truss: See illustration below. Strictly, a king 'post' carries a longitudinal ridge timber; otherwise it is designated a king 'strut' roof (see fig. A).



Generic king-post truss. The top of the king post is 'joggled' to provide a more secure abutment for the principals.

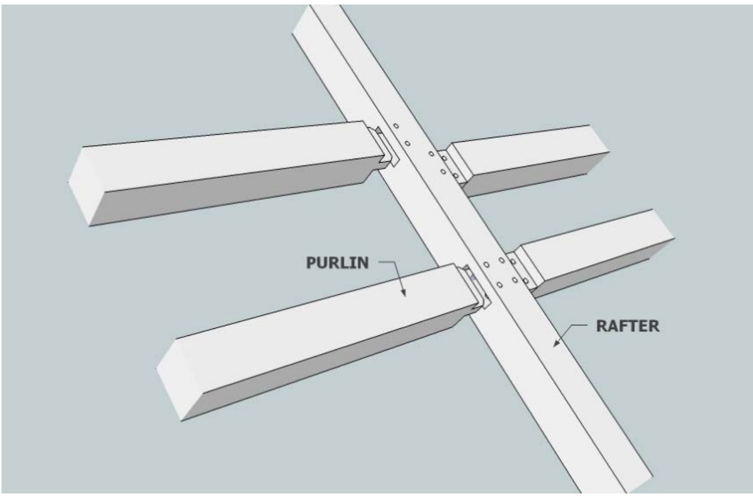
Panel Hammer Beam (author's designation): Visually, a hammer beam as two horizontal timbers: a relatively thin upper section, and a lower section in the form of a carved figure. Viewed from below, the upper section appears as a panel which frames the angel; non-structural; (cf. 'Recumbent figure hammer beam'). Eg.: Kings Lynn, Chapel of St Nicholas below.

Principal Frame: Transverse wooden framework of major structural, and often ornamental, importance, consisting of principal rafters (see below) and other major timbers; usually corresponds with masonry bay divisions (see fig. A).

Principal Rafter: Inclined timber of heavier scantling than common rafters; supports purlin(s); often corresponds with the bay divisions of a building (see fig. A).

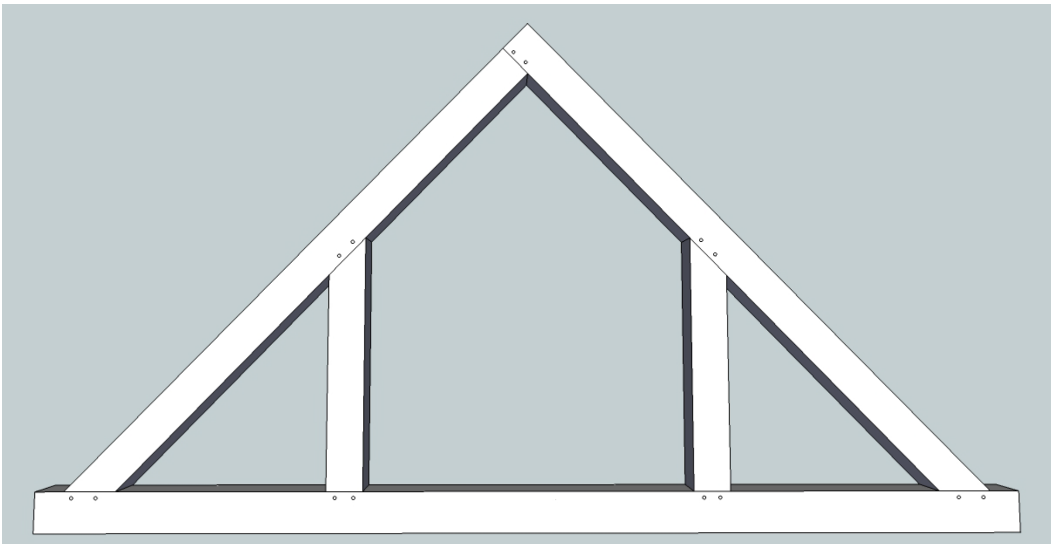
Purlin: Longitudinal roof timber supporting common rafters, usually set in the plane of the roof; framed into the principal rafters, and/or set into a masonry gable (see fig. A).

Purlin, butt: Method of framing purlin to rafter; see below.



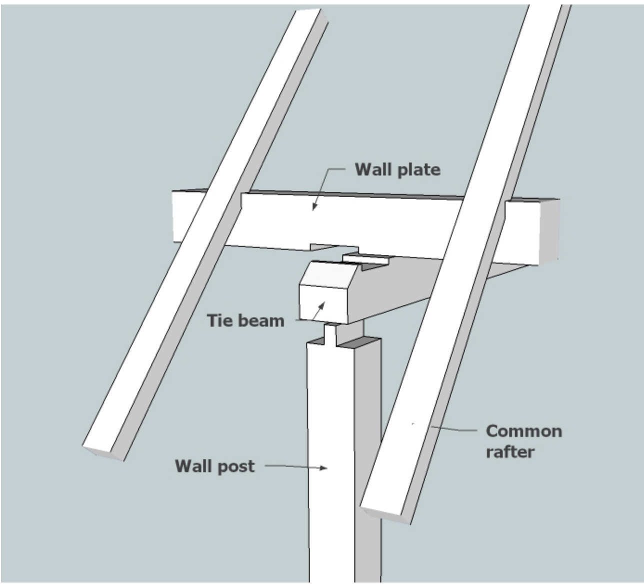
Butt purlins. Example at top is 'staggered'.

Queen Strut: See below; the two vertical timbers are queen struts.


Queen-strut truss.

Recumbent-figure Hammer Beam (RFHB): Author's designation; hammer beam carved as a prone figure, usually an angel. Eg: Westminster hall. (Cf. 'hammer beam angel')

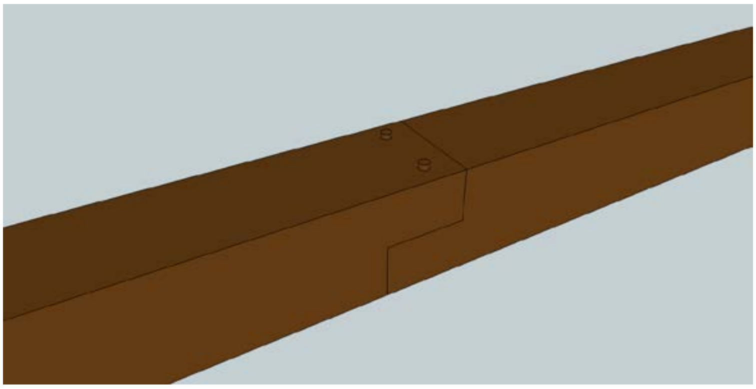
Reversed Assembly: Similar to the English Tying Joint (above), but the wall plate is placed on top of the tie beam rather than vice-versa.

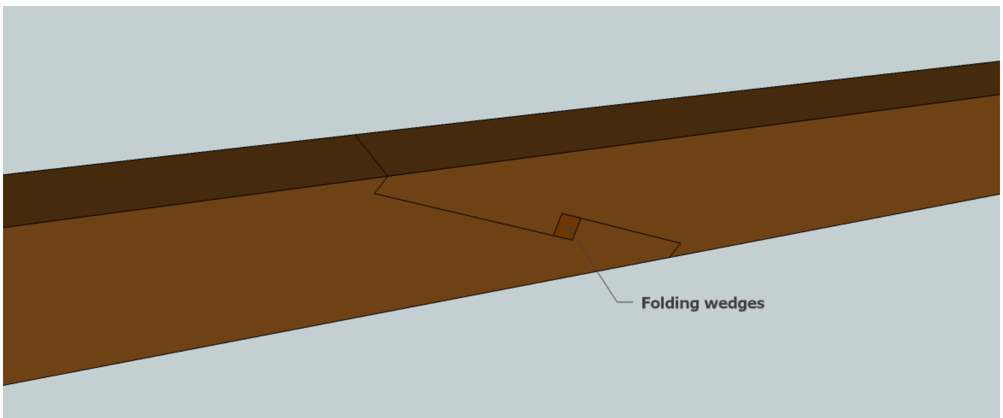


Reversed assembly

Scantling: The dimensions of a timber in section.

Scarf: Joint used to connect timbers longitudinally; of varying degrees of sophistication; see below

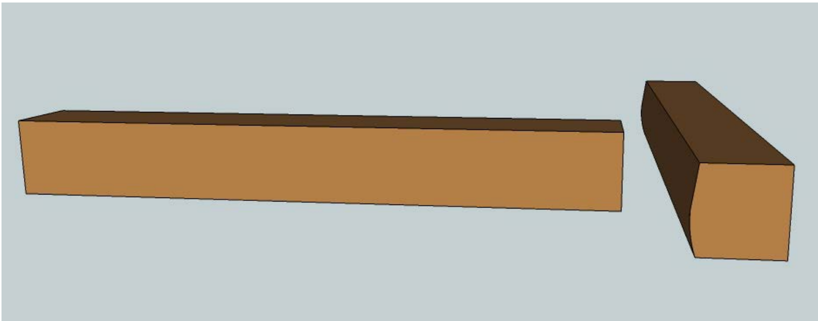




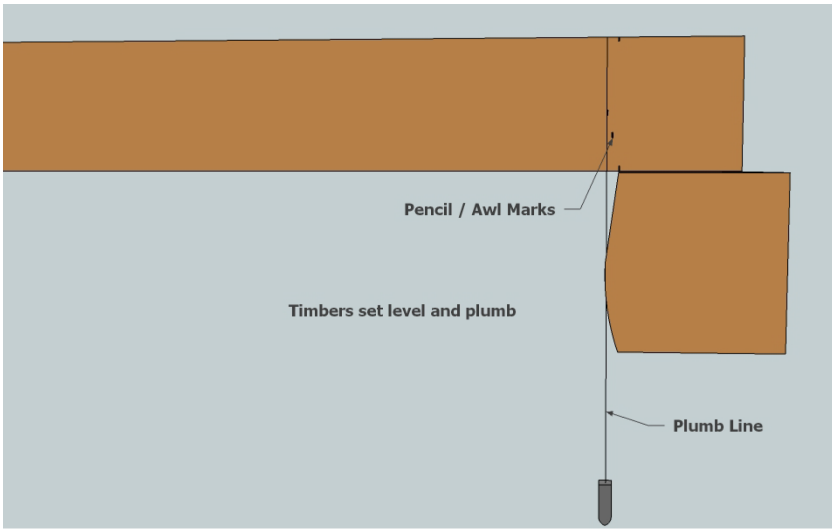
Scarf Joints, above: edge-halved; below: wedged stop-splayed and tabled with under-squinted abutments.

Scratch-stock: A hand tool used to work mouldings. The profile of the desired moulding is filed into a piece of thin steel. The profiled steel is often fastened to a wooden handle, usually with an integrated fence and depth-stop to maintain the steel in its intended position on the timber. The tool is then moved to and fro. Primarily used as a finishing tool after initial roughing-out.

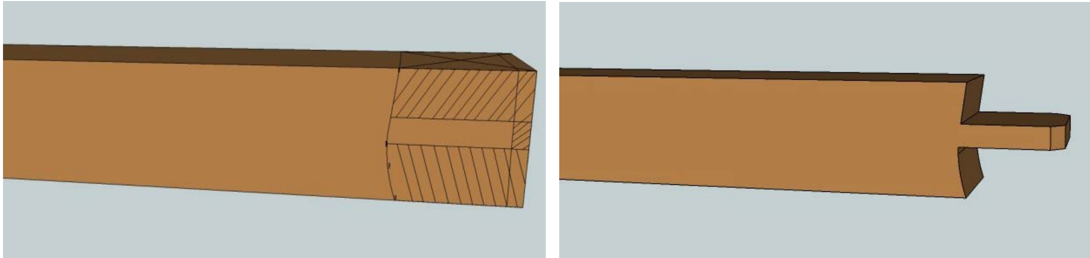
Scribing: The technique of accurately connecting mating, but irregular, surfaces. The joints of modern square-milled timbers can be marked out using simply a set square; the precise milling will ensure an accurate fit. Lacking the technology of the sawmill, medieval carpenters had to deal with irregular timbers, often hewn with an axe. To ensure a tightly fitting joint, the irregularities of the morticed face had to be reproduced on the shoulder of the tenon. This was usually done by accurately laying up the timbers, plumb and level in their final positons, and sighting along the line of a plumb-bob; see below:



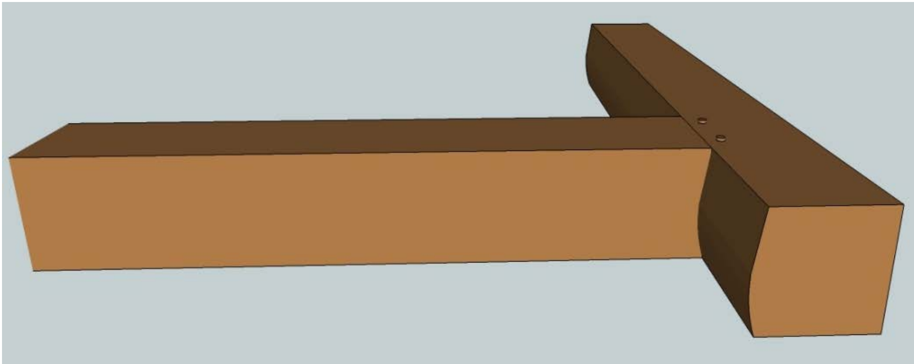
Scribing, stage 1: the timbers ready for jointing; left: tenon piece; right: mortice piece; note the irregular face of the timber to be morticed.



Scribing, stage 2: the timbers laid-up, and the profile of the mortice piece is marked on the tenon piece via sighting along a plumb line.



Scribing, stage three: the tenon fully marked out, and then (right) cut.



Scribing, final stage: a mortice has been chopped and the joint is assembled.

Soffit: The underside of a structural member.

Sole Piece: Horizontal timber at the rafter foot, set across the wall, forming a triangle with the common rafter and ashlar piece. See 'foot of rafter' above.

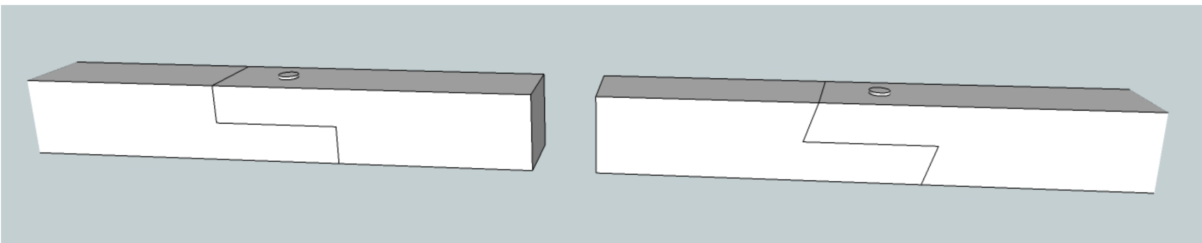
Spere Truss: A transverse partition incorporated into the main, post and beam, structure of a hall. Usually located at the 'low' end of the hall, it served to screen the service passage and exclude draughts.

Staggered Purlin: See 'purlin.'

Tie-beam: Transverse timber, usually of heavy scantling, linking the tops of the walls and / or arcade plates.

Truss: Framework of timbers set transversely, often corresponds with the bays of a structure. Strictly: a stable framework of timbers exerting no lateral thrust.

Under-squinting: Raked abutments of a joint to improve stability. See below:



Under-squinting in a simple scarf joint. Left: conventional abutment; right: under-squinted

Wall plate: Longitudinal timber at the top of a timber wall-frame or masonry wall, into which the roof timbers are framed; see fig. A.

BIBLIOGRAPHY

PRIMARY SOURCES

ADAM OF PETIT PONT, 'Adam of Petit Pont's *De Utensilibus*', in Tony Hunt (ed.) *Teaching and Learning in Thirteenth-Century England* (1991) Vol. 1, 165-76

Ancient charters of the Dean and Chapter of Chichester, 689-1674 (Chichester: Diocesan Record Office, 1972)

The Anglo-Saxon Chronicle, ed. M. Swanton (London: Everyman, 1996)

Beowulf, eds. T. A. Shippey & Andreas Haarder (London; New York: Routledge 1998)

BUCKLER, JOHN , *Sketchbooks* (London: British Library; Add. MSS 36353–36443)

The Chronicle of Adam of Usk, ed. and trans. C. Given-Wilson (Oxford: Clarendon Press, 1997)

The Chronicle of John Hardyng 1378-1465, ed. Henry Ellis (London: Printed for F. C. and J. Rivington *et al.*, 1812)

The Chronicle of Lanercost, 1272-1346, trans. Sir Herbert Maxwell (Glasgow: James Maclehose, 1913)

DAVIS-WEYER, CAECILIA (ed.), *Early Medieval Art 300-1150: Sources and Documents* (Toronto; London: University of Toronto Press in association with the Medieval Academy of America, 1986)

DIDEROT, DENIS. *L'Encyclopédie, ou dictionnaire raisonné des sciences, des arts et des metiers* (Paris: 1751–1765)

DOUVILY, SIR BALTHAZAR GERBIER, *Councel and Advise to all Builders; for the choice of their surveyours, clarks of their works, bricklayers, masons, carpenters,and other work-men therein concerned* (London: printed by Thomas Mabb, 1663)

DURANDUS, GULIELMUS, *The Symbolism of Churches and Church Ornaments*, ed. J. M. Neale & B. Webb (Leeds: T.W. Green, 1843)

The Early English South Legendary, ed. Carl Horstmann (EETS, 1887)

An English Chronicle of the Reigns of Richard II, Henry IV, Henry V, and Henry VI written before the year 1471, J. S. Davies (ed.), (New York; London: Johnson Reprint, 1968)

An English Chronicle, ed. William Marx (Woodbridge: Boydell, new ed., 2003)

ERSKINE, AUDREY M. (ed. & trans.), *The Accounts of the Fabric of Exeter Cathedral*, *1279-1353*, (Devon and Cornwall Record Society, 1981-83)

FELIBIEN, ANDRE, *Les Principes de l'architecture…* (Paris: Chez Jean-Baptiste Coignard, 1676)

FITCH, W., *A Collection of Six Hundred Water-colour Drawings, Tracings and Engravings; taken at various times between the years 1700 and 1850; illustrative of the County of Suffolk*. [Including unpublished drawings by H. Davy, newspaper cuttings, etc] (British Library)

FRISCH, TERESA. G, *Gothic Art, 1140 - 1450: Sources and Documents* (Toronto / London: University of Toronto Press, 1987)

FROISSART, JEAN, *Chronicles*, trans. & ed. Geoffrey Brereton (Harmondsworth: Penguin, 1978)

GAIMAR, GEFFREI, *Estoire des Engleis,* ed. & trans. Ian Short (Oxford: Oxford University Press, 2009)

GILLISPIE, CHARLES COULSTON, ed. *A Diderot Pictorial Encyclopaedia of Trades and* (New York: Dover Publications, 1959)

HAHNLOSER, HANS R. (ed.), *Villard de Honnecourt: Kritische Gesamtausgabe des Bauhüttenbuches ms. fr. 19093 der Pariser Nationalbibliothek* (Graz: Akademische Druck- u. Verlagsanstalt, 1972)

HARRISON, W, *The Description of England*, *1577*, Ed. G. Edelen (New York / Washington: Dover Publications / Folger Shakespeare Library, 1994)

HENRY OF HUNTINGDON, *The Chronicle of Henry of Huntingdon: comprising the history of England, from the invasion of Julius Caesar to the accession of Henry II*, ed. and trans. Thomas Forester (Felinfach: Llanerch, 1991)

HIND, ARTHUR M. (ed.), *Wenceslaus Hollar: his views of London and Windsor in the seventeenth century* (Bodley Head, 1922)

HOLLAR WENCESLAUS, *London delineavit, et fecit Londini et Antwerpiae 1647* (Prostant Amstelodami apud Cornelium Danckers in via vitulina sub insigni Gratitudines Ano.1647)

HUGH OF ST VICTOR, *The Didascalicon of Hugh of St. Victor: A Medieval Guide to the Arts,* trans. Jerome Taylor (New York: Columbia University Press, 1991)

HORMAN, WILLIAM, *Vulgaria*, [1519] (Oxford: 1926)

The Itinerary of John Leland, in or about the years 1535–1543, ed. L. Toulmin Smith, 5 vols. (London: Centaur Press, 1964)

JACOBUS DE VORAGINE, *The Golden Legend: Readings from the Saints,* trans. William Granger Ryan (Princeton; Chichester: Princeton University Press, 1993)

The Kirkstall Chronicle 1355-1400, ed. M. V. Clarke & N. Denholm-Young (Manchester: The University Press, 1931)

Knighton's Chronicle, 1337-1396, ed. G. H. Martin (Oxford: Oxford University Press, 1995)

KNOOP, D.; JONES, G. P; HAMER, D. (eds.), *The Two Earliest Masonic Mss* [The Cooke Manuscript, c. 1390-1410, and The Regius Manuscript, c.1390] (Manchester: University of Manchester, 1938)

LANGLAND, WILLIAM, *Richard the Redeless,* ed. James M. Dean (Kalamazoo, Mich.: Medieval Institute Publications, 2000)

LANGLAND, WILLIAM, *Piers the Ploughman*, trans. J. F. Goodridge (London: Penguin, revised ed., 1966)

Life of St Hugh, ed. D. L. Douie & D. H. Farmer (London: Nelson, 1962)

Londina Illustrata. Graphic and historic memorials of monasteries, churches, chapels, schools, charitable foundations, palaces, halls, courts, processions ... in the cities and suburbs of London and Westminster' (London: Robert Wilkinson, 1819)

The Luttrell Psalter, facsimile (London: The British Library, 2006 2006)

MOXON, JOSEPH. *Mechanick Exercises* (London: 3rd ed. 1703)

NATIONAL ARCHIVES, 'Works' 29 / 3299; 'Works' 29 / 3419-3597 [drawings of Westminster Hall executed by HM Office of Works, *c.* 1914, immediately prior to the roof's repair]

PHILIBERT DE L'ORME, *Le Premier Tome de l'Architecture …* (Paris: Léonce Laget, Libraire-Éditeur, 1988)

RICHARDS, GODFREY (trans.), *The First Book of Architecture by Andrea Palladio; translated out of Italian: with an appendix touching doors and windows, by Pr le Muet architect to the French King … Also rules and demonstrations, with several designs for the framing of any manner of roofs either above pitch or under pitch, whether square or bevel, never published before.* (London: Printed by J.M. and sold by G. Richards and by Sam. Thomson, 2nd ed. corrected and enlarged, 1668)

The St Albans Chronicle: The Chronica Maiora of Thomas Walsingham. Vol.1, 1376-1394, ed. John Taylor and Wendy R. Childs; trans. Leslie Watkiss (Oxford: Clarendon Press, 2002)

STUKELEY, WILLIAM, *Itinerarium Curiosum: or, an account of the antiquitys and remarkable curiositys in nature or art, observ'd in travels thro' Great Brittan* (London: 1724)

THEOPHILUS PRESBYTER, *On Divers Arts: the treatise of Theophilus*, (1110-40) trans. John G. Hawthorne and Cyril Stanley Smith (Chicago; London: University of Chicago Press, 1976)

THOMAS AQUINAS, *Commentary on Aristotle's Politics*, trans. Richard J. Regan (Indianapolis, Ind.: Hackett; Lancaster: Gazelle Drake Academic, 2007)

The Transcript of the Churchwardens' Accounts of the Parish of Tilney All Saints, Norfolk: 1443 to 1589, transcribed by A. D. Stallard (London: Mitchell Hughes and Clarke, 1922)

Roger of Wendover's Flowers of History, trans. J. A. Giles, Vol. I, pt. 2, 1066 - 1170 A.D (Felinfach: Llanerch, 1994)

The Westminster Chronicle, ed. & trans. L. C. Hector and Barbara F. Harvey (Oxford: Clarendon Press, 1982)

Wills and Inventories from the Registers of the Commissary of Bury St. Edmunds and the Archdeacon of Sudbury, ed. Samuel Tymms (London: Camden Society, 1850)

VILLARD DE HONNECOURT, *Portfolio*, Bibliothèque Nationale de France (MS Fr. 19093)

WILLIAM OF MALMESBURY, *Gesta Regum Anglorum,* ed., trans. R. A. B. Mynors (Oxford: Clarendon Press, 1998)

WILSON, THOMAS, *A Christian Dictionarie*, (1612)

SECONDARY SOURCES

ABBOTT, ERIC, *et al.*, *Westminster Abbey* (London: Weidenfeld and Nicolson, 1972)

ACLAND, JAMES A., *Medieval Structure: The Gothic Vault* (Toronto: University of Toronto Press, 1977)

ADDY, S. O, *Church and Manor: a Study in English Economic History* (London: George Allen & Co., 1913)

ADDY, S. O, *The Evolution of the English House*, ed. J. Summerson (London: Allen & Unwin, 1933)

Age of Chivalry: Art in Plantagenet England 1200-1400, eds. Jonathan Alexander & Paul Binski (London: Royal Academy of Arts, 1987)

ALCOCK, N. W., *Cruck Construction: an Introduction and Catalogue* (London: Council for British Archaeology, 1981)

ALCOCK, N. W., *Documenting the History of Houses* (London: British Records Association, 2003)

ALCOCK, N. W; BUCKLEY, R. J., 'Leicester Castle: The Great Hall', *Medieval Archaeology* 31 (1987), pp. 73-79.

ALCOCK, N. W. *et al.*, *Recording Timber-Framed Buildings: an Illustrated Glossary* (York: Council for British Archaeology, 1996)

ALDWELL, SAMUEL WILLIAM HEMPHILL, *Wingfield: its Church, Castle and College* (Ipswich: W. E. Harrison, 1925)

ALFORD, D. W. E; BARKER, T.C. *A History of the Carpenters Company* (London: Allen & Unwin, 1968)

ALLEN, JOAN, 'The Choir Stalls of Lincoln Cathedral, Chester Cathedral and St Mary's Church, Nantwich', *Journal of the British Archaeological Association*, Vol. 161 (2008), 1, 104-130

ANDERSON, SIR CHARLES, *Ancient Models, or Hints on Church Building* (London: James Burns, 1840)

ANDERSON, M. D., *The Medieval Carver* (Cambridge: CUP, 1935)

ANDERSON, M. D., *Animal Carvings in British Churches* (Cambridge: CUP, 1938)

ANDERSON, M. D., *History and Imagery in British Churches* (London: John Murray, 1971)

ANON., *A Compleat History of the Famous City of Norwich …* (London: 1728)

ANON., *The Builder's Dictionary: or, Gentleman and Architect's Companion* (London: printed for A. Bettesworth, C. Hitch and S. Austen, 1734)

ANON., 'Proposed Reconstruction of the Guildhall Roof, London', *The Builder*, 1953, 30 Jan., p. 182; [also similarly titled article, 1954, 5 Nov., p. 731-732].

ANON., *The Angel Roof, St. Mary's, Bury St. Edmunds*, (Bury St. Edmunds: 1955)

ANDREWS, FRANCIS B., *The Mediaeval Builder and his Methods* (Wakefield, Yorks.: EP Publishing Ltd., 1974)

ARMOR, NICHOLAS R., *Late Medieval Ipswich: Trade and Industry* (Woodbridge: Boydell, 2011)

ASHURST, JOHN, *Mortars, Plasters & Renders*, *English Heritage Technical Handbook* Vol. 3 (Gower Technical, 1988)

ASTLEY, H. J. D. (ed.), *Memorials of Old Norfolk* (London: Bemrose & Sons, 1908)

ATHERTON, IAN (ed.), *Norwich Cathedral: Church, City and Diocese*, *1096-1996* (London: Hambledon Press, 1996)

ATKINSON, THOMAS DINHAM, *An Architectural History of the Benedictine Monastery of Saint Etheldreda at Ely* (Cambridge: The University Press, 1933)

AULT, W. O., 'Manor Court and Parish Church in 15th century England', *Speculum* 42 (1967), p. 65.

AYERS, TIM; TATTON-BROWN, TIM, *Medieval Art, Architecture and Archaeology at Rochester* (Leeds: British Archaeological Association, 2006)

AYLMER, G.E.; CANT, REGINALD (eds.), *A History of York Minster* (Oxford: Clarendon Press, 1977)

BAILY, CHARLES, *Remarks on Timber Houses* (London: 1869)

BAILY, C., 'Monks Horton Priory' [Kent], *Archaeologia Cantiana* 10, 1876, pp. 81-9

BAILEY, GRAHAM; HUTTON, BARBARA A., *Crown Post Roofs in Hertfordshire* (Hitchin: Hertfordshire Local History Council, 1966)

BAILEY, MARK, *Medieval Suffolk1200-1500* (Woodbridge: Boydell, 2007)

BAILEY, MARK, *A Marginal Economy? East Anglian Breckland in the later Middle Ages* (Cambridge: Cambridge University Press, 1989)

BAINES, FRANK, *Report... on the condition of the roof timbers of Westminster Hall...* (London: HMSO, 1914)

BAINES, FRANK, *Photographs Illustrating the Historical Section of the Report on Westminster Hall Roof,* (London: 1914)

BAINES, SIR FRANK, 'Architecture and Sculpture', *The Realist* Vol. I, April, 1929, pp. 2-4

BARLEY, M. W., *Houses and History* (London: Faber and Faber, 1986)

BARLOW, FRANK, *William Rufus* (London: Methuen, 1983)

BARNWELL, P. S.; ADAMS, A. T., *The House Within, Interpreting Medieval Houses in Kent* (London: RCHME / HMSO, 1994)

BARNES, CARL F., *Villard De Honnecourt, the Artist and His Drawings: A Critical Bibliography* (Boston, Mass.: G.K. Hall, 1982)

BARNES, CARL F., *The Portfolio of Villard De Honnecourt: A New Critical Edition and Color Facsimile* (Farnham: Ashgate, 2009)

BARRON, CAROLINE M., 'The Quarrel of Richard II with London', in Du Boulay & Barron, (eds.), (1971), pp. 173-201

BARRON, CAROLINE M., *The Medieval Guildhall of London* (London: Corporation of London, 1974)

BARRON, CAROLINE M., 'Richard II: Image and Reality', in Dillian Gordon, *The Wilton Diptych* (London: National Gallery, 1993)

BARRON, CAROLINE M., 'Richard II and London', in Goodman & Gillespie (eds.) (1999), pp. 129-154.

BARRON, CAROLINE; SAUL, NIGEL, (eds.) *England and the Low Countries in the Late Middle Ages* (Stroud: Alan Sutton 1995)

BASING, PATRICIA, *Trades and Crafts in Medieval Manuscripts* (London: British Library, 1990)

BEAZLEY, OWEN, *Two Medieval Churches in Norfolk* (Norfolk Museums and Archaeology Service, 2001)

BECHMANN, ROLAND, *Trees and Man: The Forest in the Middle Ages*, (New York: Paragon, 1990)

BELOE, E. M., "*Our Borough"-"Our Churches*": *King's Lynn, Norfolk* (Cambridge: Macmillan & Bowes, 1899)

BENNETT, H. S, *Life on the English Manor 1150-1400,* (Cambridge: CUP., 1948)

BENSON, TEDD, *Building the Timber Frame House* (New York: Simon & Schuster/Fireside Books, 1995)

BENTHAM, JAMES, *The History and Antiquities of the Conventual & Cathedral Church of Ely: from the foundation of the monastery, A.D. 673, to the year 1771* (Norwich: Printed by and for Stevenson, Matchett, and Stevenson ..., 2nd ed., 1812)

BERGER, RAINER (ed.) *Scientific Methods in Medieval Archaeology* (Berkeley Ca.: University of California Press, 1970)

BEVIS, TREVOR, *The Angel Host at March: a Pictorial Study of the Double Hammerbeam Roof at Saint Wendreda's Church* (March: T. Bevis, 1993)

BIDDLE, MARTIN; CLAYRE, BEATRICE, *Winchester Castle and the Great Hall* (Winchester: Hampshire County Council, 1983)

Bildeston Church and Village (Bildeston P.C.C., 1987)

BINDING, GUNTHER, *Das Dachwerk auf Kirchen im Deutschen Sprachraum vom Mittelalter bis Zum...* (Deutscher Kunstverlag, 1991)

BINDING, GUNTHER, *Medieval Building Techniques* (Stroud: Tempus, 2004)

BINSKI, PAUL, *Westminster Abbey and the Plantagenets: Kingship and the Representation of Power*, 1200-1400 (Newhaven; London: Published for the Paul Mellon Centre for Studies in British Art by the Yale University Press, 1995)

BISMANIS, M. R., *The Medieval English Domestic Timber Roof: A Handbook of Types* (New York, Bern and Frankfurt: Peter Lang, 1987)

BLAIR, JOHN, 'The 12th-Century Bishop's Palace at Hereford', *Medieval Archaeology* 31 (1987), pp. 59-72

BLAIR, JOHN, 'Hall and Chamber: English Domestic Planning 1000-1250', in Meirion-Jones & Jones (eds.) (1993), pp. 1-21.

BLAIR, JOHN; RAMSEY, NIGEL (eds.)*English Medieval Industries: Craftsmen, Techniques, Products* (London: Hambledon, 1991)

BLATCHLY, JOHN; NORTHEAST, PETER*, Decoding Flint Flushwork on Suffolk and Norfolk Churches* (Ipswich: Suffolk Institute of Archaeology and History, 2005)

BLICK, SARAH; TEKKIPE, RITA (eds.) *Art and Architecture of Late Medieval Pilgrimage in Northern Europe and the British Isles* (Leiden: Brill, 2005)

BLIJDENSTIJN, ROLAND K. M.; STENVERT, RONALD, *Bouwstijlen in Nederland, 1040-1940* (Nijmegen: Sun, 2000)

BLOCKLEY, DAVID, *The New Dictionary of Civil Engineering* (London: Penguin, 2005)

BLOMEFIELD, FRANCIS, *The History of the City and County of Norwich* (Norwich: 1745

BLOMEFIELD, FRANCIS, *Essay Towards a Topographical History of the County Norfolk*, (London: William Miller, 2nd ed., 1805-1810)

BLOXHAM, MATTHEW; WARWICKSHIRE NAT. HIST. & ARCHAEOL. SOCIETY, *Notices of the Churches of Warwickshire, Deanery of Warwick* (Warwick: Henry T. Cooke, 1847-58)

BOND, FRANCIS, *Gothic Architecture in England* (London: Batsford, 1906)

BOND, FRANCIS, *Screens and Galleries in English Churches* (Oxford: OUP, 1908)

BOND, FRANCIS, *Westminster Abbey* (London: Henry Frowde, 1909)

BOND, FRANCIS, *Wood Carvings in English Churches*, Vol. I: *Misericords*; Vol. II: *Stalls and Tabernacle Work, Bishops' Thrones and Chancel Chairs* (London: Oxford University Press 1910)

BOND, FRANCIS, *An Introduction to Church Architecture, From the 11th to the 16th Centuries*, (Oxford: OUP, 1913)

BONNEY, HELEN '"Balle's Place", Salisbury: a 14th-Century Merchant's House', *Wiltshire Archaeological Magazine,* 59 (1964), pp. 155-67.

BONNEY, H. K., *Bonney's Church Notes: Being Notes on the Churches in the Archdeaconry of Lincoln 1845-1848*, ed. Reverend N. S. Harding (Lincoln: Keyworth & Sons, 1937)

BONY, JEAN, *The English Decorated Style: Gothic Architecture Transformed 1250-1350* (Oxford: Phaidon, 1979)

BORK, ROBERT *et al.* (eds.), *New Approaches to Medieval Architecture* (Farnham: Ashgate, 2011)

BOUTELL CHARLES; BRITTON, JOHN, *Illustrations of the Early Domestic Architecture of England* (London: David Bogue, 1846)

BOWSHER, DAVID *et al.*, *The London Guildhall: an Archaeological History of a Neighbourhood from Early Medieval to Modern Times,* 2 Vols. (London: Museum of London Archaeology Service, 2007)

BRANDON, RAPHAEL & J. ARTHUR, *Norfolk Churches: Comprising Twenty-Four Views of Some of the Most Interesting Ecclesiastical Remains in the County.* (London: G. Bell, 1847)

BRANDON, RAPHAEL & J. ARTHUR, *Parish Churches* (London: Bell, 1848)

BRANDON, RAPHAEL & J. ARTHUR, *The Open Timber Roofs of the Middle Ages* (London: James Rimmell & Son, new ed., 1873)

BRANDON, RAPHAEL & J. ARTHUR *Analysis of Gothic Architecture* (Edinburgh: Grant, 1903)

BRANNER, ROBERT, *St. Louis and the Court Style in Gothic Architecture* (London: A. Zwemmer, 1965)

BRAUN, HUGH, *Parish Churches: Their Architectural Development in England* (London: Faber, 1970)

BRITISH ARCHAEOLOGICAL ASSOCIATION, *Medieval Art and Architecture at Gloucester and Tewkesbury* (Leeds: British Archaeological Association, 1985)

BRITISH ARCHAEOLOGICAL ASSOCIATION, *Medieval Art and Architecture at Lincoln Cathedral* (British Archaeological Association, 1986)

BRITTON, JOHN, *The Architectural Antiquities of Great Britain* (London: Longman, Hurst, Rees & Orme, 1807-1809)

BRITTON, JOHN, *The History and Antiquities of the See and Cathedral Church of Winchester* (London: Longman & Co., 1817)

BRITTON, JOHN, *Picturesque Antiquities of the English Cities* (London: Longman, Rees, Orme, Brown *et al.*, 1830)

BRITTON, JOHN, *A Dictionary of the Architecture and Archaeology of the Middle Ages* (London: Longman, Orme, Brown, Green and Longmans; and the author, 1838)

BRITTON, JOHN; BRAYLEY, EDWARD WEDLAKE, *The History of the Ancient Palace and Late Houses of Parliament at Westminster* ... (London: John Weale, 1836)

BROWN, G. BALDWIN, *The Arts in Early England*, Vol. 2: *Ecclesiastical architecture in England from the Conversion of the Saxons to the Norman Conquest* (London: John Murray 1903)

BROWN, G. BALDWIN, 'The Work of the Mediæval Builder', *RIBA J.* Vol. XXIX, No. 19 (1922)

BROWN, SARAH, *York Minster: an Architectural History, c. 1220-1500* (English Heritage, 2003)

BROWNE, WILLIS, *A Survey of the Cathedrals of York, Durham, Carlisle, Chester, Man, Lichfield, Hereford, Worcester, Gloucester, and Bristol…* (London: printed for R. Gosling, 1727)

BRUNSKILL, R. W., Review: 'Vernacular Architecture: A Review of Recent Literature: *English Historic Carpentry* by C. A. Hewett', *Architectural History* Vol. 26, (1983), pp. 108, 109.

BRUNSKILL, R. W., *The Illustrated Handbook of Vernacular Architecture* (London: Faber& Faber, 4th ed., 2000)

BRUNSKILL, R. W., *Timber Building in Britain* (New Haven and London: Yale University Press, 2nd ed., 2007)

BRYANT, T. H., *Norfolk Churches*, 19 Vols, (Norwich: 1898-1906)

BUCHANAN, P, 'Stirling Castle, Great Hall Hammerbeam Roof', in Janet Kleboe (ed.), *Timber and the Built Environment* (Edinburgh: Historic Scotland, 2002).

BUCHER, FRANCOIS, *Architector: The Lodge and Sketchbooks of Medieval Architects* (New York: Araris Books, 1979)

BUCKLER, JOHN CHESSELL, *An Historical and Descriptive Account of the Royal Palace at Eltham* (London: J.B. Nichols and Son, 1828)

BUCKTON, DAVID; HESLOP, T. A. (eds.), *Studies in Medieval Art and Architecture Presented to Peter Lasko*, (Stroud: Alan Sutton in association with the Trustees of the British Museum, 1994)

The Builder (London: 1842-1966)

BUGGE, ANDERS RAGNAR, *Norwegian Stave Churches* (Oslo: Dreyer, 1953)

BURGESS, CLIVE; DUFFY, EAMON (eds.), *The Parish in Late Medieval England: Proceedings of the 2002 Harlaxton Symposium* (Donington: Shaun Tyas, 2006)

BURY, THOMAS TALBOT, *Remains of Ecclesiastical Woodwork* (London: J. Weale, 1847)

BUXTON, J; WILLIAMS, P. (eds.), *New College Oxford, 1379–1979* (Oxford: The Warden and Fellows of New College, 1979)

CAIGER-SMITH, A., *English Medieval Mural Paintings* (Oxford: Clarendon Press, 1963)

CALDICOTT, J. R., *Simon de Montfort* (Cambridge: CUP, 1994)

CALMETTE, JOSEPH, *Charles V* (Paris: A. Fayard, 1945)

CAMMIDGE, JOHN, *The Black Prince: an Historical Pageant* (London: Eyre and Spottiswoode, 1943)

CAMP, A. J., *Wills and their Whereabouts* (London: Phillimore & Co., 1963)

CAMPBELL, DAVID, *Wood in Traditional Architecture*, (Schiffer Publishing Ltd., 2011)

CANNADINE, DAVID *et al.*, *The Houses of Parliament: History, Art, Architecture*. (London: Merrell Publishers, 2000)

CANNON, JON; WILLIAMSON, BETH (eds.) *The Medieval Art, Architecture and History of Bristol Cathedral* (Woodbridge: Boydell, 2011)

CARTER, JOHN, *Views of Ancient Buildings in England, drawn in different tours … commencing 1764* (London: J. Carter 1786-93)

CARTER, JOHN, *Specimens of the Ancient Sculpture and Painting, now Remaining in this Kingdom*, (London: J. Carter, 1780)

CARTER, JOHN; BASIRE, JAMES, *Plans, Elevations, Sections, and Specimens of the Architecture and Ornaments, of the Remaining Parts of St. Stephens Chapel, Westminster: erected by Edward III* (London: Society of Antiquaries, *c.* 1811)

Catalogue of Maps, Prints, Drawings, etc., Forming the Geographical and Topographical Collection Attached to the Library of his Late Majesty King George the Third (London, 1829)

CATTERMOLE, PAUL; COTTON, S, 'Medieval Parish Church Building in Norfolk', *Norfolk Archaeology* 38 (1983), pp. 235-279.

CATTERMOLE, PAUL, 'A 14th Century Contract for Carpenter's Work at Ashwellthorpe Church', *Norfolk Archaeology* 40, no. 3 (1989), pp. 297-299.

CATTERMOLE, PAUL (ed.), *Wymondham Abbey* (Wymondham: Wymondham Abbey Book Committe, 2007)

CAUTLEY, H. MUNRO, *Suffolk Churches and their Treasures* (Woodbridge: The Boydell Press, 5th Ed., 1982)

CAUTLEY, H. MUNRO, *Norfolk Churches* (Ipswich, Norman Adlard & Co., 1949)

CAVELER, WILLIAM, *Select specimens of Gothic Architecture, comprising the ancient and most approved examples in England* (London: M. Taylor, 2nd ed., 1839)

CAVINESS, MADELINE HARRISON, 'Reception of Images by Medieval Viewers', in Rudolph, ed., (2006), pp. 65-85

CESCINSKY, HERBERT; GRIBBLE, E. R., *Early English Furniture and Woodwork*, 2 Vols. (London: The Waverley Book Company Ltd., 1922)

CESCINSKY, HERBERT; GRIBBLE ERNEST R., 'Westminster Hall and Its Roof', *The Burlington Magazine for Connoisseurs,* Vol. 40, No. 227 (Feb., 1922), pp. 76-79, 82-84.

CHAPPELL, STEVE, *A Timber Framer's Workshop* (Brownfield, Maine: Fox Maple Press, 1998)

CHARLES, F.W.B. *The Conservation of Timber Buildings* (Shaftsbury: Donhead, 1995)

CHASE, STEVEN, *Angelic Spirituality: Medieval Perspectives on the Ways of Angels* (New York: Paulist Press, 2002)

CHIEFFO RAGUIN, VIRGINIA; BRUSH, KATHRYN; DRAPER, PETER (eds.), *Artistic Integration in Gothic Buildings* (Buffalo; London: University of Toronto Press, 1995)

CHILD, HEATHER; COLLES, DOROTHY, *Christian Symbols, Ancient and Modern*, (London: Bell, 1971 1971)

‘Church Roofing’, *The Ecclesiologist* 3, Nos. 31-32, May 1844.

CLAGETT, MARSHAL, *The Science of Mechanics in the Middle Ages* (University of Wisconsin Press, 1959)

CLAPHAM, A. W. *English Romanesque Architecture, Vol. 2, After the Conquest* (Oxford: Clarendon Press, 1934)

CLAPHAM, A. W; GODFREY, WALTER H., *Some Famous Buildings and their Story* (Westminster: Technical Journals, 1913)

CLARKE, GEORGIA; CROSSLEY PAUL (eds.), *Architecture and Language: Constructing Identity in European Architecture, 1000-1600* (Cambridge: Cambridge University Press, 2000)

CLARKE, J., ‘An Early Vernacular Hammer-beam Structure: Imberhorne Farm Cottages, East Grinstead, West Sussex’, *Vernacular Architecture* 36 (2005), pp. 32-40.

CLAYTON, JOHN, *Ancient Timber Edifices of England* (London: Thomas McLean, 1846 1840)

CLIFTON-TAYLOR, ALEC, *The Pattern of English Building* (London : Faber and Faber, 1972)

CLIFTON-TAYLOR, ALEC, *The Cathedrals of England* (London: Thames & Hudson, revised ed., 1986)

CLUTTON-BROCK, A., *York, The Cathedral and See* (London: George Bell & Sons, 3rd ed., 1909)

COALDRAKE, W. H., *The Way of the Carpenter* (New York: Weatherhill, 1990)

COKE, T: KIDSON, P., *Salisbury Cathedral: Perspectives on the Architectural History* (London: Royal Commission on Historical Monuments (England), HMSO, 1993)

COLDSTREAM, NICOLA (ed.), *Medieval Art and Architecture at Ely Cathedral*, (The British Archaeological Association, 1979)

COLDSTREAM, NICOLA, *The Decorated Style: Architecture and Ornament, 1240-1360* (London: British Museum, 1994)

COLDSTREAM, NICOLA, *Medieval Architecture* (Oxford: OUP, 2002)

COLLING, JAMES KELLAWAY, *Gothic Ornaments*, 2 Vols. (London: Bell, 1848-1850)

COLLING, JAMES KELLAWAY, *Details of Gothic Architecture,* 2 Vols. (London: Bogue, 1852-1856)

COLVIN, H. M. (ED.), *The History of the King's Works,* Vols. 1 & 2 (London: HMSO, 1963)

COLVIN, HOWARD MONTAGU*, A Guide to the Sources of English Architectural History* (Shalfleet Manor (Isle of Wright): Pinhorns, 1967)

CONANT, KENNETH J., *Carolingian and Romanesque Architecture: 800 to 1200* (Harmondsworth: Penguin, 1959)

COOK, A. K., *About Winchester College* (London: Macmillan, 1917)

COOK, G. H., *The English Mediaeval Parish Church* (London: Phoenix House, 3rd ed., 1961)

COOPER, IVY M, 'Westminster Hall, The Meeting-places of Parliaments in the Ancient Palace of Westminster', *Journal of the British Archaeological Association*, 1936, pp. 25-27.

COOPER, IVY M., *Westminster Hall* (Nottingham: Cooke & Vowles, the Thoroton Press, 1937)

COOPER, IVY M., 'Westminster Hall and the Meeting Places of Parliament in the Ancient Palace of Westminster'*, Journal of the British Archaeological Association*, 1938, pp 97-138.

COOPER, LISA H., *Artisans and Narrative Craft in Late Medieval England* (Cambridge: CUP, 2011)

COOPER, NICHOLAS, 'Burmington Manor, Warwickshire; the C13th building', *RCHME Annual Review*, 1984-5, pp. 27-30

CORDINGLEY, R. A., 'British Historical Roof-Types and Their Members: A Classification', *Transactions of the Ancient Monuments Society* IX (London: The National Monuments Society, 1961), pp. 73-118

CORLETTE, HUBERT CHRISTIAN, *The Cathedral Church of Chichester: a Short History & Description of its Fabric with an Account of the Diocese and See* (London: G. Bell, 1911)

COTTINGHAM, LEWIS, NOCKALLS, *Westminster Hall* (London: Rodwell and Martin, 1822)

COTTON, SIMON, 'Perpendicular Churches', in Hicks (ed.), 1997, pp. 95-106.

COURTENAY, L. T., 'Westminster Hall and its Fourteenth-century Sources', *Journal of the Society of Architectural Historians*, Vol. 43, No. 4 (Dec. 1984), pp. 295–309.

COURTENAY, L. T. 'Where Roof Meets Wall: Structural Innovations and Hammer-beam Antecedents', in Pamela O. Long ed., *Science and Technology in Medieval Society* (New York: The New York Academy of Sciences, 1985), pp. 89-124.

COURTENAY, L. T., 'The Westminster Hall Roof: A New Archaeological Source,' *Journal of the British Archaeological Association* 143 (1990), pp. 95-111.

COURTENAY, L. T. (ed.), *The Engineering of Medieval Cathedrals* (Aldershot: Ashgate Variorum, 1997)

COURTENAY, L. T., 'Scale and Scantling: Technological Issues in Large-Scale Timberwork of the High Middle Ages,' in, Smith & Wolfe, (eds.), 1997, pp. 42-75.

COURTENAY, L. T; MARK, ROBERT, 'The Westminster Hall Roof: A Historiographic and Structural Study', *Journal of the Society of Architectural Historians,* Vol. 46, No. 4 (Dec., 1987), pp. 374-393

COX, C., *Country Churches, Norfolk* (George Allen, 2nd ed., 1911)

COX, J. CHARLES, *Churchwardens Accounts from the Fourteenth Century to the Close of the Seventeenth Century* (London: Methuen & Co., 1913)

COX, J. CHARLES, *The English Parish Church* (London: B. T. Batsford 1914)

CREWE, SARAH, *Stained Glass in England: C.1180-C.1540* (London: H.M.S.O., 1987)

CROOK, J, 'The Pilgrims' Hall, Winchester', *Proc. Hants. Field Club Archaeological Society*, 38 (1982), pp. 85-101.

CROOK, J, 'The Pilgrims' Hall, Winchester, Hammerbeams, Base Crucks and Aisle-Derivatives', *Archaeologia* 109 (1991), 129-159

CROSSLEY, FRED H., *English Church Monuments A. D. 1150-1550* (London: Batsford, 1921)

CROSSLEY, FRED. H, *English Church Craftsmanship* (London: Batsford, 2nd ed., 1947)

CROSSLEY, FRED. H, *Timber Building in England, From Early Times to the End of the Seventeenth Century*, (London: Batsford, 1951)

CROSSLEY, PAUL, 'Medieval Architecture and Meaning: The Limits of Iconography', *Burlington Magazine,* 130 (1988), 116-21.

CUDWORTH, C. L., 'Dutch Influence in East Anglian Architecture', *Proceedings of the Cambridge Antiquarian Society* 37, 1935.

CUSTANCE, R. (ed.), *Winchester College: Sixth-centenary Essays* (Oxford: OUP, 1982)

DALE, THOMAS E. A., 'The Monstrous', in Rudolph (ed.), 2006, pp. 253-273.

DANIELL, CHRISTOPHER, *Death and Burial in Medieval England, 1066-1550* (London: Routledge, 1997)

DARBY, H. C., *The Medieval Fenland* (Newton Abbot: David and Charles, 1974)

DARROCH, ELIZABETH, *A Bibliography of Norfolk History* (Norwich: University of East Anglia, Centre of East Anglian Studies, 1975)

DAVEY, N, *A History of Building Materials* (London: Phoenix House, 1961)

DAVIES, R. G.; DENTON, J. H. (eds.), *The English Parliament in the Middle Ages* (Manchester: Manchester University Press, 1981)

DAVIES, RICHARD G., 'Richard II and the Church', in Goodman & Gillespie (eds.), 1999, pp. 83-106

DAVIS, VIRGINIA, *William Wykeham: A Life* (London: Hambledon Continuum, 2007)

DAVY, DAVID ELISHA, *A Journal of Excursions through the County of Suffolk 1823-44,* ed. John Blatchly (Woodbridge: Published for the Suffolk Records Society by the Boydell Press, 1982)

DAY, JAMES WENTWORTH, *A History of the Fens* (London: George G Harrap and Co Ltd, 1954)

DENEUX, HENRI, 'L'evolution des Charpentes…', *L'Architecte*, (1927)

DENDOOVEN, LUCIEN, *L'abbaye de Ter Doest à Lissewege-Bruges* (Bruges: Éditions Ter Doest, 4th ed., 1972)

DIETRICHSON, LORENTZ, *de Norske Stavkirker* (Christiania; Kjøbenhavn, 1892)

DOIG, ALLAN, *Liturgy and Architecture: From Early Church to the Middle Ages* (Aldershot: Ashgate, 2008)

DOLLMAN, F. T; JOBBINS, I. R., *An Analysis of Ancient Domestic Architecture in Great Britain,* (London: Batsford, 1861)

DOWN, ALEC (ed.), *Chichester Excavations* 4 & 5 (Chichester: Phillimore, for Chichester Civic Society Excavations Committee, 1979 & 1981)

DOWSING, WILLIAM, *The Journal of William Dowsing: Iconoclasm in East Anglia during the English Civil War,* ed. Trevor Cooper (Woodbridge: Boydell & Brewer, 2001)

DOYLE, *Parish Church of Great Shelford* (Ramsgate: Church Publishers, 1962)

DRINKWATER, N., 'The Old Deanery, Salisbury', *Antiquaries Journal* 44 (1964), pp. 41-59

DRYDEN, ALICE, *Memorials of Old Warwickshire* (London: Bemrose, 1908)

DU BOULAY, F. R. H.; BARRON, CAROLINE M. (eds.), *The Reign of Richard II* (London: University of London, 1971)

DUBY, GEORGES, *The Age of the Cathedrals: Art and Society 980-1420* (London: Croom Helm, 1981)

DUFFY, EAMON, 'The Parish, Piety and Patronage in Late Medieval East Anglia: The Evidence of Rood Screens', in French, Gibbs & Kumin (eds.), 1997, pp. 133-162.

DUFFY, MARK, *Royal Tombs of Medieval England* (Stroud: Tempus Publishing, 2003)

Dugdale, William, *Monasticon Anglicanum, a History of the Abbies and other Monasteries, Hospitals, Frieries, and Cathedral and Collegiate Churches with their Dependencies, in England and Wales* [1655] (London: 1718)

DUNLOP, IAN, *Royal Palaces of France* (London: Hamilton, 1985)

DUNNAGE, H; LAVER, C., *Plans, Elevations, Sections, Details, and Views, of the Great Hall of the Royal Palace of Eltham, in Kent* (London: J. Taylor, and Priestley & Weale, 1828)

DYER, ALAN, *Decline and Growth in English towns, 1400-1640* (Basingstoke: Macmillan Education, 1991)

DYER, CHRISTOPHER, *Making a Living in the Middle Ages: The People of Britain, 850-1520* (New Haven & London: Yale University Press, 2002)

DYER, CHRISTOPHER, *Everyday Life in Medieval England* (London: Hambledon, 1994)

DYMOND, DAVID; MARTIN, EDWARD (eds.), *An Historical Atlas of Suffolk* (Ipswich: Suffolk county Council; Suffolk Institute of Archaeology and History, 3rd ed.revised, 1999)

DYMOND, DAVID; PAINE, CLIVE, *Five Centuries of an English Parish Church: 'the State of Melford Church', Suffolk* (Cambridge: EAH Press, 2012)

EAMES, PENELOPE, *Furniture in England, France and the Netherlands from the Twelfth to the Fifteenth Century* (London: The Furniture History Society, 1977)

EASTLAKE, CHARLES L., *History of the Gothic Revival* (London: 1872)

EBERLE, PATRICIA J., 'Richard II and the Literary Arts', in Goodman & Gillespie (eds.), 1999, pp. 231-254.

ELLIS, GEORGE, *Modern Practical Carpentry* (London: Batsford, 3rd ed. revised, 1927 [1st ed., 1906])

ELMES, JAMES, *Memoirs of the Life and Works of Sir Christopher Wren …* (London: Priestley and Weale, 1823)

EMERSON, BARBARA, *The Black Prince* (London: Weidenfeld & Nicholson, 1976)

EMERY, A, *Dartington Hall* (Oxford: The Clarendon Press, 1970)

EMERY, A, *Greater Medieval Houses of England and Wales, 1300-1500,* 3 Vols. (Cambridge: CUP, 1996)

EMERY, A, *Discovering Medieval Houses* (Oxford: Shire, 2007)

EMERY, PHILIP A.; HEATH, JACQUELINE A., 'Making a Grand Entrance: Conservation and Archaeology in Westminster Hall, the Palace of Westminster, London', *Association for Studies in the Conservation of Historic Buildings Transactions*, Vol. 31, 2008, pp. 3-16

ENGLISH HERITAGE, *Dendrochronology: Guidelines on Producing and Interpreting Dendrochronogical Dates* < www.english-heritage.org.uk>

ÉPAUD, FRÉDÉRIC, *De la Charpente romane à la charpente gothique en Normandie: l'évolution des techniques et des structures de charpenterie du XIIe au XIIIe siècles* (Caen: Publications du CRAHM, 2007)

EVANS, JOAN, *English Art, 1307-1461* (Oxford: Clarendon Press, 1949)

EVELYN-WHITE, E. H., *Cambridgeshire and the Isle of Ely* (George Allen & Co., 1911)

FAWCETT, RICHARD, ‘The Influence of the Gothic parts of the Cathedral on Church-building in Norfolk’, in Atherton (ed.) 1996, pp. 210-228.

FAWCETT, RICHARD, *Stirling Castle: The Restoration of the Great Hall* (York: CBA, 2001)

FELDHAUS, F. M., *Die Sage* (Berlin, 1921)

FERNIE, ERIC; CROSSLEY, PAUL, *Medieval Architecture and its Intellectual Context* (London: Hambledon Continuum, 1990)

FERNIE, ERIC, *A Beginner's Guide to the Study of Architectural Proportions and Systems of Length,* in Fernie & Crossley (eds.), 1990, pp. 229-38)

FERNIE, ERIC, *The Architecture of Norman England* (Oxford: OUP, 2000)

FITCHEN, JOHN, *The Construction of Gothic Cathedrals* (Chicago & London: University of Chicago Press, 1961)

FITCHEN, JOHN, *Building Construction Before Mechanization* (Cambridge, Mass. & London: MIT Press, 1986)

FLEMING, JOHN; HONOUR, HUGH; PEVSNER, NIKOLAUS, *The Penguin Dictionary of Architecture and Landscape Architecture* (London: Penguin, 5th ed., 1998)

FLETCHER, JOHN, ‘Medieval timberwork at Ely’, in Coldstream (ed.), 1979, pp. 58-70.

FLETCHER, CHRISTOPHER, *Richard II: Manhood, Youth, and Politics, 1377-99* (Oxford: Oxford University Press, 2008)

FORRESTER, HARRY, *Medieval Gothic Mouldings* (London; Chichester: Phillimore, 1972)

FLETCHER, J. M; SPOKES, P. S, ‘The Origin and Development of Crown-Post Roofs’, *Medieval Archaeology* 8 (1964), pp. 152-183.

FRANKL, PAUL, *Gothic Architecture*, revised by Paul Crossley (New Haven; London: Yale University Press, 2000)

FRANKL, PAUL, *The Gothic: Literary Sources and Interpretations Through Eight Centuries* (Princeton: Princeton University Press, 1960)

FRANKLIN-BROWN, MARY, *Reading the World: Encyclopaedic Writing in the Scholastic Age* (Chicago, Ill.: University of Chicago Press, 2012), FREMONT, CHARLES, 'La Scie', *Societe d'encouragement pour l'industrie nationale Bulletin*, (1928), pp. 643-721

FRENCH, K. L.; GIBBS, G. G.; KUMIN, B. A. (eds.), *The Parish in English Life 1400-1600* (Manchester: Manchester University Press, 1997)

FRENCH, K.L., 'Parochial Fund-raising in Late Medieval Somerset', in French, Gibbs & Kumin (eds.), 1997, pp. 115-132

FRENCH, K. L., *The People of the Parish: Life in a Late Medieval English Diocese* (Philadelphia, Pennsylvania: University of Pennsylvania Press, 2001)

GARDNER, ARTHUR, *English Medieval Sculpture* (Cambridge: CUP, new ed., 1951)

GARLAND, ROBERT; MOULE, THOMAS; WINKLES, B., *Cathedral Churches of England and Wales,* 2 Vols. (London: 1838)

GARRISON, PHILIP, *Basic Structures for Engineers and Architects* (Oxford: Blackwell, 2005)

GEE, E. A., 'Oxford Carpenters, 1370–1530', *Oxoniensia*, 17–18 (1952–3), pp. 112–84.

GEE, ERIC, *A Glossary of Building Terms used in England from the Conquest to c.1550* (Frome: Frome Historical Research Group, 1984)

GERHOLD, DORIAN, *Westminster Hall: Nine Hundred Years of History* (London: James & James, 1999)

GIBSON, GAIL MCMURRAY, *The Theater of Devotion: East Anglian Drama and Society in the Late Middle Ages* (Chicago & London: University of Chicago Press, 1989)

GILLESPIE, JAMES L. (ed.), *The Age of Richard II* (Stroud: Sutton, 1997)

GILLESPIE, JAMES L., 'Richard II King of Battles?', in Gillespie (ed.), 1997, pp. 139-164.

GIMPEL, JEAN, *The Cathedral Builders* (London: Pimlico, 1993)

GIVEN-WILSON, CHRISTOPHER, *Chronicles of the Revolution, 1397-1400* (Manchester: Manchester University Press, 1993)

GIVEN-WILSON, CHRISTOPHER (ed.), *The Parliament Rolls of Medieval England 1275-1504*, Vol. 7: *Richard II, 1385-1397* & Vol. 8: *Henry IV, 1399-1413* (Woodbridge: Boydell Press; London: National Archives, 2005)

GOODALL, JOHN A. A., *God's House at Ewelme: Life, Devotion and Architecture in a Fifteenth-century Almshouse* (Aldershot: Ashgate, 2001)

GOODMAN, ANTHONY; GILLESPIE, JAMES L. (eds.), *Richard II The Art of Kingship* (Oxford: OUP, 1999)

GOODMAN. ANTHONY, 'Richard II's Councils', in Goodman & Gillespie (eds.), 1999, pp. 59-82

GOODMAN, W. L., *The History of Woodworking Tools* (London: Bell & Hyman, 1964)

GORDON, DILLIAN, *The Wilton Diptych* (London: National Gallery, 1993)

GORDON, DILLIAN; MONNAS, LISA; ELAM, CAROLINE (eds.), *The Regal Image of Richard II and the Wilton Diptych* (London: Harvey Miller, 1997)

GORDON, J. E., *Structures, or Why Things Don't Fall Down* (London: Penguin, 1978)

GOTCH, J. ALFRED, *The Growth of the English House, from Early Feudal Times to the Close of the Eighteenth Century*, (London: Batsford, 1928)

GRANGER, PENNY, *The N-Town Play: Drama and Liturgy in Medieval East Anglia* (Cambridge: D. S. Brewer, 2009)

GRANSDEN, ANTONIA, *Historical Writing in England* , Vol. II: *1307 to the Early Sixteenth Century* (London: Routledge & Kegan Paul Ltd., 1982)

GRANSDEN, ANTONIA, *Bury St Edmunds: Medieval Art, Architecture, Archaeology and Economy* (British Archaeological Association, 1998)

GRENVILLE, JANE, *Medieval Housing* (London: Leicester University Press, 1997)

GRODECKI, LOUIS; PRACHE, ANNE; RECHT, ROLAND, *Gothic Architecture*, (London: Faber, 1986)

HALL, HUBERT; NICHOLAS, FRIEDA J., 'Select Tracts and Table Books Relating to English Weights and Measures (1100-1742)', *Camden Miscellany*, Vol.15 (London: Offices of the Society, 1929)

HALLAM, H. E. (ed.), *The Agrarian History of England and Wales II: 1042-1350* (Cambridge: CUP, 1988)

HANSEN, HANS JURGEN, *Architecture in Wood: History of Wood Building and Its Techniques in Europe and North America*, (London: Faber & Faber, 1971)

HARPER, JOHN, *The Forms and Orders of Western Liturgy …* (Oxford: Clarendon Press, 1991)

HARPER-BILL, CHRISTOPHER (ed.), *East Anglia's History* (Boydell, [in association with] The Centre of East Anglian Studies, University of East Anglia 2002)

HARPER-BILL, CHRISTOPHER (ed.), *Medieval East Anglia* (Woodbridge: Boydell Press, 2005)

HART, J. COLEMAN., *Designs for Parish Churches in the Three Styles of English Church Architecture* (New York: Dana, 1857)

HARRIS, ESMOND; HARRIS, JEANETTE; JAMES, N. D. G., *Oak: A British History* (Macclesfield: Windgather, 2003)

HARRIS, RICHARD, 'The Grammar of Carpentry', *Vernacular Architecture* 20 (1989), pp. 1-8.

HARRIS, RICHARD, *Discovering Timber-Framed Buildings* (Princes Risborough, Bucks: Shire Publications Ltd., 3rd ed., 2006)

HARRISON, WILLIAM, *The Description of England* (New York: Dover, 1994)

HARRISS, G. L., 'The Formation of Parliament', in Davies & Denton (eds.), 1981, pp. 29-60.

HARVEY JOHN H., 'The Mediaeval Carpenter and his Work as an Architect', *RIBA Journal*, 45 (1937–8), pp. 733–43

HARVEY, JOHN H, *Henry Yevele* (London: Batsford, 1946)

HARVEY, JOHN H., 'The King's Chief Carpenters', *Journal of the British Archaeological Association*, 3rd ser., 11 (1948), pp. 13–34

HARVEY, JOHN H., *Gothic England: a Survey of National Culture 1300-1500* (London: Batsford, 2nd ed., 1948)

HARVEY, JOHN H., *The Gothic World*, 1100-1600 (London: Batsford, 1950)

HARVEY, JOHN H., 'Architectural Archives …', *Archives*, Vol. II (1954), pp. 117-122

HARVEY, JOHN H., 'Mediaeval Design', *Trans. Ancient Monument Society*, new series, Vol. VI (1958), pp. 55–72

HARVEY, JOHN H., 'The Wilton Diptych – A Re-examination', *Archaeologia* 98 (1961), pp. 1-24.

HARVEY, JOHN H., *The Mediaeval Architect* (London: Wayland, 1972)

HARVEY, JOHN H., *Medieval Craftsmen* (London: Batsford, 1975)

HARVEY, JOHN H., *The Perpendicular Style 1330-1485* (London: Batsford, 1978)

HARVEY, JOHN H., *English Mediaeval Architects: a Biographical Dictionary Down to 1550* (Gloucester: Alan Sutton, 2nd ed. revised, 1984)

HARVEY, WILLIAM, 'Westminster Hall and the Woodman', *The Builder*, 1921, Vol. 121, 19 Aug, pp. 220-221

HARVEY, WILLIAM, 'Westminster Hall Roofs, Old and New', *The Builder*, 1921, Vol. 121, 23 Sept, pp. 374-375

HARVEY, WILLIAM, *Models of Buildings, How to Make and Use Them* (London: The Architectural Press, 1927)

HASLAM, RICHARD, 'Wingfield College, Suffolk', *Country Life*, Vol. 171 (1982), Jan. 7, pp. 18-21.

HASLAM, RICHARD, 'The Palace, Chichester, West Sussex: the seat of the Bishop of Chichester', *Country Life,* Vol. 180 (1986), 21 August, pp. 560-64.

HASTINGS, MAURICE, *St. Stephen's Chapel and its Place in the Development of Perpendicular Style in England* (Cambridge: CUP, 1955)

HAWARD, BIRKIN, *Suffolk Medieval Church Arcades*, *1150-1550* (Ipswich: Suffolk Institute of Archaeology and History 1993)

HAWARD, BIRKIN, *Suffolk Medieval Church Roof Carvings: A Photographic Survey of Carvings on Hammerbeam Roofs* (Ipswich: Suffolk Institute of Archaeology and History 1999)

HAWARD, BIRKIN, *Master Mason Hawes of Occold, Suffolk & John Hore, Master Carpenter of Diss: a Tribute to Two Fifteenth-Century Master Craftsmen* (Ipswich: Suffolk Institute of History and Archaeology, 2000)

HAYTER, Sir WILLIAM, *William of Wykeham: Patron of the Arts* (London: Chatto & Windus, 1970)

HEARN, M. F.; THURLBY, M., ‘Previously Undetected Wooden Rib-vaults in Medieval Britain’, *Journal of the British Archaeological Association,* 150 (1997), pp. 48-58

HESLOP, T. A., ‘Swaffham Parish Church’, in Harper-Bill (ed.), 2005, pp. 246-271.

HEWETT, CECIL A., *Church Carpentry: a Study Based on Essex Examples* (London: Phillimore, 1974)

HEWETT, CECIL A., ‘Aisled Timber Halls and Related Buildings, Chiefly in Essex’, *Trans. Ancient Monuments Society*, 21 (1976), 45-99.

HEWETT, CECIL A., *English Cathedral and Monastic Carpentry* (Chichester: Phillimore, 1985)

HEWETT, CECIL A., 'English Medieval Cope Chests', *Journal of the British Archaeological Association,* 141 (1988), pp. 105-24.

HEWETT, CECIL A., *English Historic Carpentry* (Fresno, Ca.: Linden, 1997 [1st ed. 1980])

HEYMAN, JACQUES, ‘Westminster Hall Roof’, *Proceedings of the Institution of Civil Engineers*, 37 (1967), pp. 137-162

HEYMAN, JACQUES, *The Masonry Arch* (Chichester: Ellis Horwood, 1982)

HEYMAN, JACQUES, ‘Letters’, *Journal of the Society of Architectural Historians*, Vol. 47, No. 3 (Sep., 1988), pp. 322-323.

HEYMAN, JACQUES, *The Stone Skeleton: Structural Engineering of Masonry Architecture* (Cambridge: Cambridge University Press, 1995)

HEYMAN, JACQUES, *Arches, Vaults and Buttresses* (Aldershot: Variorum, 1996)

HEYMAN, JACQUES, *Basic Structural Theory* (Cambridge: Cambridge University Press, 2008)

HEYMAN, JACQUES, *Timber Vaults* (University of Cambridge, Department of Architecture Downloads, 2012) <www.arct.cam.ac.uk>

HICKS, CAROLA, *Cambridgeshire Churches* (Stamford: Paul Watkins, 1997)

HIGHAM, ROBERT; BARKER, PHILIP, *Timber Castles* (Mechanicsburg, PA: Stackpole Books, 1995)

HILL, NICK, ‘The Manor House, Medbourne: the Development of Leicestershire's Earliest Manor House’, *Leicestershire Archaeological &. Historical Soc. Trans.* 75 (2001), pp 36-61

HINDLE, B. P., *Medieval Roads and Tracks* (Botley, Oxford: Shire, 2011)

HISCOCK, NIGEL, *The Wise Master Builder: Platonic Geometry in Plans of Medieval Abbeys and Cathedrals* (Aldershot: Ashgate, 2000)

History and Description of Westminster Hall, Extracted ... from the New Times (London: printed for George Dalton, 1829)

HOBBS, MARY, *Chichester Cathedral: An Historical Survey* (Chichester: Phillimore, 1994)

HOFFSUMMER, PATRICK, *Les Charpentes de toitures en Wallonie: typologie et dendrochronologie XIe-XIXe siècle* (1995)

HOFFSUMMER, PATRICK, *Roof Frames from the 11th to the 19th Century: Typology and Development in Northern France and in Belgium* (Turnhout, Belgium: Brepols, c.2009)

HOLLES, GERVASE, 1606-1675, *Lincolnshire Church Notes*, ed. R. E. G. Cole (Woodbridge: Boydell Press, 2010)

HOLT, ELIZABETH GILMORE (ed.), *A Documentary History of Art*, Vol I: *The Middle Ages and the Renaissance* (Princeton: Princeton University Press, 1981)

HORN, WALTER, ‘The Potential and Limitations of Radiocarbon Dating in the Middle Ages: The Art Historians View’, in Berger (ed.), 1970, pp. 23-87

HORN, WALTER; BORN, ERNEST, *The Barns of the Abbey of Beaulieu at its Granges of Great Coxwell and Beaulieu-St Leonards* (Berkeley: University of California Press, 1965).

HORN, WALTER; BORN, ERNEST, *The Plan of St. Gall: a Study of the Architecture and Economy of, and Life in, a Paradigmatic Carolingian Monastery* (Berkeley; London: University of California Press, 1979)

HOSKIN, PHILIPPA M.*, Chichester, 1254-1305* (Oxford: Oxford University Press for the British Academy, 2001)

HOWARD, F. E, ‘On the Construction of Medieval Roofs’, *Archaeological Journal* Vol. 71, 1914, pp. 293-352.

HOWARD, F. E., *The Mediaeval Styles of The English Parish Church: A Survey of Their Development, Design and Features* (London: Batsford, 1936)

HOWARD, F. E; CROSSLEY, F.H., *English Church Woodwork: a Study in Craftsmanship during the Mediaeval Period* (London: Batsford, 1917)

HUGHES, J. QUENTIN, 'The Timber Roofs of York Minster', *Yorkshire Archaeological Journal* XXXVIII, pt. 152 (1955), pp. 474-495.

HURST, J. G., 'Rural Building in England and Wales: England', in Hallam (ed.) 1988, pp. 854-930.

HUSA, VACLAV, *Traditional Crafts and Skills: Life and Work in Mediaeval and Renaissance Times* (London: Paul Hamlyn, 1968)

HUSS, GEORGE MARTIN, *Rational Building* (New York: 1895)

HUTTON, RONALD, *The Rise and Fall of Merrie England* (Oxford: Oxford University Press, 1994)

HUTCHINSON, HAROLD F., *The Hollow Crown, a Life of Richard II* (London: Eyre and Spottiswoode, 1961)

IMPEY, EDWARD, 'Seigneurial Domestic Architecture in Normandy, 1050-1350', in Meirion-Jones & Jones (eds.), 1993, pp. 82-120

INNOCENT, C. F, *The Development of English Building Construction* (Newton Abbot: David & Charles, 1971).

JACKSON, M. J. (ed.), *Engineering a Cathedral: Durham* (London: Thomas Telford, 1993)

JAMES, ELIZABETH; BEGLEY, MICHAEL, *St Nicholas' Chapel, King's Lynn, Norfolk* (London: The Churches Conservation Trust, 2000)

JAMES, MONTAGUE, RHODES, *St Georges Chapel Windsor: The Woodwork of the Chapel*, (Windsor: Oxley and Son, 1933)

JAMES, T. B., *The Palaces of Medieval England* (London: Seaby, 1990)

JANSE, H., *Houten Kappen in Nederland 1000-1940* (Delft: Delftse Universitaire Pers, 1989)

JAY, W., 'The House of Commons and St Stephen's Chapel', *English Historical Review,* XXXVI (1921), pp. 226-228.

JOHNSON, MATTHEW, *Housing Culture: Traditional Architecture in an English Landscape* (London: UCL Press, 1993)

JOHNSON, MATTHEW, *Behind the Castle Gate: from Medieval to Renaissance* (London: Routledge, 2002)

JONES, CHRISTOPHER, *The Great Palace: The Story of Parliament* (London: BBC, 1983)

JONES, TIMOTHY S.: SPRUNGER, DAVID A. (eds.), *Marvels, Monsters, and Miracles: Studies in the Medieval and Early Modern Imaginations* (Kalamazoo, Mich.: Western Michigan University, 2002)

JORDAN, SARAH, 'What is The Impact of Increasing Change in Wind Patterns on Building Design and Operations?', *Scoping Report*, 2010 <www.environmentalevidence.org>

JOUSSE, MATHURIN, *L'Art de charpenterie...* Corrigé & augmenté ... par M. De La Hire (Paris: Troisieme edition, 1751)

JUPP, EDWARD BASIL, *An Historical Account of the Worshipful Company of Carpenters of the City of London* (London, Pickering,1848)

KANTOROWICZ, ERNST, *Laudes Regiae, a Study in Liturgical Acclamations and Medieval Ruler Worship* (Berkeley and Los Angeles: University of California Press, 1958)

KARSTKAREL, Peter, *Alle Middeleeuwse Kerken* (Groningen: Noordboek, 2008)

KEEN, LAURENCE; COCKE, THOMAS (eds.), *Medieval Art and Architecture at Salisbury Cathedral* (Tring: British Archaeological Association 1996)

KEEN, LAURENCE; SCARFF, EILEEN (eds.), *Windsor: Medieval Archaeology, Art and Architecture of the Thames Valley* (Leeds: British Archaeological Association / Maney, 2002)

KEENE, D. J., RUMBLE, A. R., *A Survey of Medieval Winchester* (Oxford: Clarendon Press, 1985)

KELLY, FRANCIS (ed.) *Medieval Art and Architecture at Exeter Cathedral* (British Archaeological Association, 1991)

KELVIN, NORMAN (ed.), *The Collected Letters of William Morris*, Vol.3, 1889-1892 (Princeton; Chichester: Princeton University Press, 1996)

KEMPE, A. J., 'The Mote at Ightham, Kent', *The Gentleman's Magazine*, Vol. 7 (1837), pp. 152-56.

KENDRICK, LAURA, 'Marginalised Images in Manuscripts', in Rudolph ed. (2006), pp. 274-293

KIPLING, GORDON, *Enter the King: Theatre, Liturgy, and Ritual in the Medieval Civic Triumph* (Oxford: Clarendon Press, 1998)

KIRBY, J. L., *Henry IV of England* (London: Constable, 1970)

KIRBY, THOMAS F., *Annals of Winchester College: From its Foundation in the Year 1382 to the Present Time* (London: H. Frowde, 1892)

KLEBOE, JANET (ed.), *Timber and the Built Environment* (Edinburgh: Historic Scotland, 2004)

KNOTT, SIMON, *The Norfolk Churches Site,* <www.norfolkchurches.co.uk>; *The Suffolk Churches Site,* <www.suffolkchurches.co.uk>

KRAFFT, JOHANN CARL, *Traité sur l'Art de la charpente* … trans. R. Cooper (Paris: 1819-22)

KRAUS, HENRY, *Gold was Mortar: The Economics of Cathedral Building* (London: Routledge and Kegan Paul, 1979)

KRAUTHEIMER, R., 'Introduction to the "Iconography" of Medieval Architecture', *Journal of the Warburg and Courtauld Institutes,* 5 (1942), pp. 1-33

KRAUTHEIMER, R, *Studies in Early Christian, Medieval and Renaissance Art,* (NewYork and London, 1969)

LANCASHIRE, A, 'Early London Pageants and Theater History Firsts', *Shakespeare Studies,* 30 (2002), pp. 84-93

LAIRD, ROSS A., *Grain of Truth: The Ancient Lessons of Craft* (Toronto: Macfarlane Walter & Ross, *c.* 2001)

LAMBARDE, WILLIAM, *A Perambulation of Kent, conteining the description, hystorie, and customes of that Shire, written in the yeere 1570* (Chatham; London: Baldwin, Cradock & Joy, 1826)

LANGLEY, BATTY, *Ancient Masonry, Both in the Theory and Practice...* (London: printed for, and sold by the author; J. Milan; and J. Huggonson, 1736)

LAWSON, TERENCE; KILLINGRAY, DAVID (eds.) *An Historical Atlas of Kent* (Chichester: Phillimore, 2004)

LEACH, ARTHUR FRANCIS, *A History of Winchester College* (London: Duckworth, 1899)

LEACH, PETER E., Unpublished drawings of the roof framing in the hall of Ightham Mote, Kent (2001)

LEEDY, W. C., *Fan Vaulting: Study of Form, Technology and Meaning* (London: Scolar, 1980)

LEPOW, L., *Enacting the Sacrament: Counter-Lollardy in the Townely Cycle* (London: Associated University Presses, 1990)

LETHABY, W. R., *Westminster Abbey and the King's Craftsmen* (London: Duckworth & Co., 1906)

LETHABY, W. R., 'The Palace of Westminster in the Eleventh and Twelfth Centuries', *Archaeologia*, Vol. LX (1906), pp. 131-148.

LEWIN, STEPHEN, *Lincolnshire Churches: An Account of the Churches in the Division of Holland in the County of Lincoln* (Boston, Lincs.: 1843)

LEWIS, ELIZABETH, *et al.*, *Medieval Hall Houses of the Winchester Area* (Winchester: Winchester City Museum, 1988)

LEVIN, Ed, 'Hammer-beam Roofs I', *Timber Framing* 48, June 1998, pp. 12-16

LEVIN, ED, 'Hammer-beam Roofs II', *Timber Framing* 49, September 1998, pp. 10-11.

LINDLEY, PHILLIP, 'Absolutism and Regal Image in Ricardian Sculpture', in Gordon, Monnas & Elam (eds.), 1997, pp. 31-84.

LLOYD, NATHANIEL, *History of the English House* (London: The Architectural Press, 1975 [first pub. 1931])

LONG, EDWARD T., 'Painted Roofs in East Anglian Churches', *The Burlington Magazine for Connoisseurs* , Vol. 55, No. 317 (Aug., 1929), pp. 74-77, 80-81

LONG, PAMELA O. (ed.) *Science and Technology in Medieval Society* (New York: New York Academy of Sciences, 1985).

LUTTON, ROBERT, *Lollardy and Orthodox Religion in pre-Reformation England* (Woodbridge: the Royal Historical Society & Boydell Press, 2011)

LYSONS, REV. DANIEL; LYSONS, SAMUEL, *Magna Britannia: being a concise topographical account of the several counties of Great Britain*, Vol. II, pt. 1: *Cambridgeshire* (London: Printed for T. Cadell and W. Davies, 1806-22)

MADDISON, JOHN, *Ely Cathedral Design and Meaning* (Ely: Ely Cathedral Publications, 2000)

MAINSTONE, ROWLAND, *Developments in Structural Form* (Harmondsworth: Penguin, 1975)

MAINSTONE, ROWLAND 'Letters', *Journal of the Society of Architectural Historians*, Vol. 47, No. 3 (Sep., 1988), pp. 321-322

MAINSTONE, ROWLAND, 'Structural Analysis, Structural Insights, and Historical Interpretation', *Journal of the Society of Architectural Historians* , Vol. 56, No. 3 (Sep., 1997), pp. 316-340.

MARK, ROBERT, *Experiments in Gothic Structure* (Mass.: MIT Press; New edition, 1984)

MARK, ROBERT (ed.), *Architectural Technology up to the Scientific Revolution: The Art and Structure of Large-scale Buildings* (Cambridge, Mass., London: MIT Press, 1993)

MARREY, BERNARD, *Des Histoires de bois*, (Paris: Editions du Pavillon de l'Arsenal: Picard, 1994)

MASON, EMMA, *William II: Rufus, the Red King* (Stroud: Tempus, 2005)

MASON, REGINALD THOMAS, *Framed Buildings of England* (Horsham: Coach Publishing House Ltd., 1974)

MAZEROLLE, LOUIS, *Traité théorique et pratique de charpente* (Dourdan, 1922)

MCGRAIL, SEÁN, *Woodworking Techniques before 1500* (Oxford: B.A.R., 1982)

MCGRAIL, SEÁN, *Ancient Boats in North-West Europe: the Archaeology of Water Transport to AD 1500* (London: Longman, 1998)

MCGRAIL, SEÁN, *Ancient Boats and Ships* (Princes Risborough: Shire, 2nd ed., 2002)

MCHARDY, A. K. (ed., trans.), *The Reign of Richard II* (Manchester: Manchester University Press, 2012)

MCKISACK, MAY, *The Fourteenth Century 1307-1399* (Oxford: Clarendon Press, 1959)

MCLEAN, TERESA, *The English at Play in the Middle Ages* (Windsor Forest: Kensal, 1983)

MCNEILL, JOHN, *King's Lynn and the Fens: Medieval Art, Architecture and Archaeology* (British Archaeological Association Conference Transactions, 2008)

MEADOWS, PETER; RAMSAY, NIGEL (eds.), *A History of Ely Cathedral* (Woodbridge: Boydell 2003)

MELLINKOFF , RUTH, *Outcasts: Signs of Otherness in Northern European Art of the Late Middle Ages* (Oxford: University of California Press, 1993)

MERCER, ERIC, *Furniture 700-1700* (London: Weidenfeld & Nicolson, 1969)

MERCER, ERIC, *English Vernacular Houses: A Study of Traditional Farmhouses and Cottages* (London: H.M.S.O., 1975)

MERCER, ERIC, *English Architecture to 1900: the Shropshire Experience* (Almeley, Herefordshire: Logaston Press, 2003)

MERCER, HENRY C. *Ancient Carpenters' Tools* (Doylestown, Pennsylvania: The Bucks County Historical Society, 1951)

MEIRION-JONES, GWYN, 'The Roof Carpentry of Brittany', *Vernacular Architecture* 9 (1978), 17.

MEIRION-JONES, GWYN; JONES, MICHAEL (eds.), *Manorial Domestic Buildings in England and Northern France* (London: Society of Antiquaries of London, 1993)

MEIRION-JONES, GWYN; JONES, MICHAEL; PILCHER, JON R., 'The Seigneurial Domestic Buildings of Brittany, 1000-1700', in Meirion-Jones & Jones (eds.), 1993, pp. 158-191.

MIDDLETON-STEWART, JUDITH, *Records of the Churchwardens of Mildenhall* (Woodbridge: Boydell, 2011)

MIDDLETON-STEWART, JUDITH, 'Parish Activity in late Medieval Fenland', in Burgess & Duffy (eds.), 2006, pp. 282-301.

MILES, D. W. H., *The Tree-Ring Dating of the Roof Carpentry of … Salisbury Cathedral* (English Heritage, 2002)

MILES, D. W. H., 'Refinements in the Interpretation of Tree-Ring Dates for Oak Building Timbers in England and Wales', *VA* 37 (2006), 84-96

MIŁOBĘDZKI, ADAM, 'Architecture in Wood: Technology, Symbolic Content, Art', *Artibus et Historiae,* Vol. 10, No. 19 (1989), pp. 177-206

MILNE, GUSTAV, *Timber Building Techniques in London c. 900-1400: an Archaeological Study of Waterfront Installations and Related Material* (London: London and Middlesex Archaeological Society, 1992)

MILNER, JOHN, *A Treatise on the Ecclesiastical Architecture of England during The Middle Ages* (London: J. Taylor, 1811)

MILNER, M., 'Bracing Philosphy in Trussed Rafter Roofs', *The Structural Engineer*, Volume 74, No 9/7, May 1996, pp. 153-156.

MOBERLY, GEORGE HERBERT, *Life of William of Wykeham* (Winchester: Warren & Son, 1887)

MOLES, ANTOINE, *Histoire des charpentiers* (Paris: 1949)

MONCKTON, LINDA, 'The Late Medieval Rebuilding of Sherborne Abbey: A Reassessment', *Architectural History* , Vol. 43, (2000), pp. 88-112

MOORE, CHARLES HERBERT, *The Medieval Church Architecture of England* (Macmillan, 1912)

MORGAN, B. G., *Canonic Design in English Mediaeval Architecture: the Origins and Nature of Systematic Architectural Design in England, 1215-1515* (Liverpool: Liverpool University Press, 1961)

MORRELL, J. B., *Woodwork in York* (London: Batsford, 1949)

MORRIS, C. A, *Anglo-Saxon and Medieval Woodworking Crafts: the Manufacture and Use of Domestic and Utilitarian Wooden Artifacts in the British Isles, 400-1500 a.d.* (Ph.D thesis, University of Cambridge, 1984)

MORRIS, CAROL A, *Craft, Industry and Everyday Life: Wood and Woodworking in Anglo-Scandinavian and Medieval York* (CBA: 2000)

MORRIS, M. G; PERRING, F. H. (eds.), *The British Oak: Its History and Natural History* [B.S.B.I. Conference Reports, Number Fourteen] (Classey, 1974).

MORRIS, RICHARD K., *The Development of Later Gothic Mouldings in England c. 1250-1400*: Part I, *Architectural History* Vol. 21, (1978), pp. 18-57; pt II: 1979, 1-48

MORRIS, RICHARD, *Cathedrals and Abbeys of England and Wales* (London: Dent, 1979)

MORRIS, THOMAS, 'Glances at the Structural Principle of the Roof of Westminster Hall …', *Royal Institute of British Architects Proceedings,* 1st series, Vol. 3, 1849-1850, pp. 3-8 [229-234].

MORRIS, THOMAS, *Brief Chapters on British Carpentry: History and Principles of Gothic Roofs* (London: Simpkin, Marshall & Co., 1871)

MORRIS, WILLIAM, 'Manifesto for the Establishment of SPAB' (London: 1877)

MORRISON, J. H., *The Underhills of Warwickshire* (Cambridge: Printed privately at the University Press, 1932)

MORRISS, R. K., *The Buildings of Shrewsbury* (Stroud: Alan Sutton, 1993)

MORRISS, R. K., *The Archaeology of Buildings* (Stroud: Tempus, 1999)

MORTIMER, IAN, *The Perfect King* (London: Vintage, 2008)

MORTLOCK, D. P; ROBERTS, C. V., *The Guide to Norfolk Churches* (Cambridge: Lutterworth Press, 2nd ed., 2007)

MORTLOCK, D.P. *The Guide to Suffolk Churches,* 3 Vols (Cambridge: Acorn Editions, 1988-92)

MOSELEY, THOMAS, 'Open Roofs', *British Critic 29*, April, 1841.

MOXON, JOSEPH, *Mechanick Exercises: or the Doctrine of Handy-works* (London: 1703)

MUNBY, JULIAN, 'Medieval Carpentry at Chichester', in Down (ed.), 1981, pp. 229-253.

MUNBY, JULIAN, 'Thirteenth-Century Carpentry in Chichester', *Archaeological Journal.*, 142, (1985) 13-17.

MUNBY, JULIAN, 'Wood', in Blair, & Ramsey (eds.), 1991, pp. 379-405.

MUNBY, JULIAN, 'Manorial Building in Timber in Central and Southern England 1200-1550', in Meirion-Jones & Jones (eds.), 1993, pp. 49-64.

MUNBY JULIAN; SPARKS, M., & TATTON-BROWN, T, 'Crown Post and King Strut Roofs in South-East England', *Medieval Archaeology* 27 (1983), pp. 123-135.

MUNRO, JOHN H. A., *Textiles, Towns and Trade: Essays in the Economic History of Late-medieval England and the Low Countries* (Aldershot, Hampshire: Variorum, 1994)

MURRAY, STEPHEN, 'The Study of Gothic Architecture', in Rudolph (ed.), 2006, pp. 382-402

MYERS, A. R. (ed.), *English Historical Documents 1327-1485* (London: Eyre & Spottiswoode, 1969)

MYRC, JOHN, *Instructions for Parish Priests,* edited from Cotton MS Claudius A. II by Edward Peacock (London: Early English Text Society, 1868)

MYRC, JOHN, *How thow schalt thy paresche preche: John Myrc's Instructions for parish priests,* (c. 1403) eds. Geoffrey F. Bryant and Gordon A. Plumb (Barton-on-Humber: Workers' Educational Association, Barton-on-Humber Branch, 2003)

NASH, JOSEPH, *The Mansions of England in Olden Times* (London: William Heinemann, new ed., 1912)

NEWMAN, RUPERT, *Oak-Framed Buildings* (Lewes: The Guild of Master Craftsman Publications Ltd., 2005)

NEVE, RICHARD *The City and Country Purchaser, and Builder's Dictionary: or, The Compleat Builder's Guide ...* (London: Printed for D. Browne *et al.*, 2nd ed.1726)

NICHOLAS, DAVID, *Trade, Urbanisation and the Family: Studies in the History of Medieval Flanders* (Aldershot: Variorum, 1996)

NICHOLS, ANN ELJENHOLM, *The Early Art of Norfolk: A Subject List of Extant and Lost Art Including Items Relevant to Early Drama (*Michigan: Medieval Institute Publications, Western Michigan University, 2002)

NICHOLSON, PETER, *The Carpenter and Joiner's Assistant; containing practical rules for making all kinds of joints ... Also extracts from M. Belidor, M. du Hamel, M. de Buffon &c. On the strength of timber, with practical observations* (London: Printed for I. and J. Taylor, 1797)

NICHOLSON, PETER, *The Carpenter's New Guide: being a complete book of lines for carpentry and joinery...* (London: printed for J. Taylor, 6th ed., 1814)

NICHOLSON, PETER, *An Architectural Dictionary, Containing a Correct Nomenclature and Derivation of the Terms Employed* (London: Printed by J. Barfield, 1819)

NICHOLSON, PETER *The New Practical Builder and Workman's Companion* (London: printed for Thomas Kelly, 1823)

NISBETT, N. H. C., 'Notes on the Roof of the Pilgrims Hall, Winchester', *Proceedings of the Hants. Field Club Archaeol. Soc.* 3, (1894), pp. 71-77.

NORTHEAST, PETER, 'Suffolk Churches in the Later Middle Ages', in Harper-Bill (ed.), 2002, pp. 93-106

NORTHEAST, PETER, Unpublished notes, Suffolk Record Office HD 2448/1/1/474

O'MARA, VERONICA, *Four Middle English Sermons* (Heidelberg: Winter, 2002)

OSTENDORF, FRIEDRICH, *Geschichte des Dachwerks* (Berlin: 1908)

OVITT, GEORGE JR., *The Restoration of Perfection: Labor and Technology in Medieval Culture* (New Brunswick, N.J.: Rutgers University Press, 1987)

OWEN, DOROTHY, M., *Church and Society in Medieval Lincolnshire* (Lincoln: Lincolnshire Local History Society, History of Lincolnshire Committee, 1971)

OXFORD SOCIETY FOR PROMOTING THE STUDY OF GOTHIC ARCHITECTURE, *The rules of the Oxford Society for promoting the Study of Gothic Architecture* (Oxford, 1841)

OXLEY, RICHARD, 'Surveying Historic Timber-Framed Buildings' *RICS Building Conservation Journal*, No. 24, Winter/Spring 2000.

OXLEY, RICHARD, *The Survey and Repair of Traditional Buildings: A Sustainable Approach* (Shaftesbury: Donhead 2003)

PAGE, STUART, Unpublished drawings of the roof framing in the hall of Ightham Mote, Kent (2001)

PAIN, WILLIAM, *The Builder's Companion, and Workman's General Assistant* (London: Printed for the author, and Robert Sayer, 1762)

PAIN, WILLIAM, *The Practical House Carpenter or Youth's Instructor* (London: John Weale, 4th ed., 1792)

PAINE, C. R., *St Mary's Bury St Edmunds* (2000)

PALEY, F. A., *Manual of Gothic Mouldings* (London: 1865)

PARKER, J.H., *Some Account of Domestic Architecture in England,* 3 Vols. (Oxford: Parker, 1853-59)

PARKER, J.H., *et al.*, *The Ecclesiastical and Architectural Topography of England: Suffolk* (Oxford: J.H. & J. Parker, 1855)

PARSONS, DAVID, *Books and Buildings: Architectural Description Before and after Bede* (Jarrow: Parochial Church Council of the Parish of Jarrow, c1988)

PARSONS, DAVID, *Churches and Chapels: Investigating Places of Worship* (London: Council for British Archaeology, 1989)

PARSONS, DAVID (ed.), *Stone: Quarrying and Building in England AD 43-1525* (Chichester: Phillimore in association with The Royal Archaeological Institute, 1990)

PEARSON, J. L., *Report from the Select Committee on Westminster Hall Restoration: together with the proceedings of the Committee, minutes of evidence and appendix* (London: 1884)

PEARSON, SARAH, *The Medieval Houses of Kent* (London: HMSO 1994)

PEARSON, SARAH; BARNWELL P. S; ADAMS A.T., *A Gazetteer of Medieval Houses in Kent* (London: HMSO, 1994)

PENISTAN, M. J., 'Growing Oak', in Morris & Perring (eds.), 1974, pp. 98-111.

PERROY, EDOUARD (ed.), *The Diplomatic Correspondence of Richard II* (London: Royal Historical Society, 1933)

PEVSNER, NIKOLAUS, 'Terms of Architectural Planning in the Middle Ages', *Journal of the Courtauld and Warburg Institutes* (1942)

PEVSNER, NIKOLAUS, *The Buidings of England*, Multiple volumes, (Harmondsworth: Penguin Books, 1951-)

PEVSNER, NIKOLAUS, 'Architecture in Our Time', *The Listener*, 5 January 1967, pp. 8-10.

PEVSNER, NIKOLAUS, *Some Architectural Writers of the Nineteenth Century* (Oxford: Clarendon Press, 1972)

PHILLIPS, SEYMOUR, *Edward II* (New Haven, Conn.; London: Yale University Press, 2010)

PINTO, EDWARD HENRY, *The Craftsman in Wood* (London, 1962)

PIPPARD, A. J. S., *Strain Energy Methods of Stress Analysis* (London: Longmans & Co., 1928)

PLAT, GABRIEL, *L'art de Bâtir en France des Romains à l'an 1100* (Paris: Les Éditions d'art et d'histoire 1939)

PLATT, COLIN, *The English Medieval Town* (London: Secker and Warburg, 1976)

PLATT, COLIN, *The Parish Churches of Medieval England* (London: Secker & Warburg, 1981)

PLATT, COLIN, *The Architecture of Medieval Britain: a Social History* (New Haven, Conn.; London: Yale University Press, 1990)

POLLEN, J. H., *Ancient and Modern Furniture and Woodwork in the South Kensington Museum,* revised by T. A. Lehfeldt, (London: HMSO, 1908)

PORT, M. H., *The Palace of Westminster, Surveyed on the Eve of the Conflagration, 1834* (London Topographical Society, 2011)

PORTAL, MELVILLE, *The Great Hall of Winchester Castle*, (Winchester: Warren, 1899)

PORTER, ARTHUR KINGSLEY, *Medieval Architecture: its Origins and Development, with Lists of Monuments and Bibliographies,* 2 Vols. (London: Batsford, 1909)

POUNDS, NORMAN J. G., *Cambridgeshire: a History of Church and Parish*, (Cambridge: Oleander, 2003)

PRICE, FRANCIS, *The British Carpenter: or, A Treatise on Carpentry: containing the most concise and authentick rules of that art, in a more useful and extensive method, than has been made publick* (London: Printed by C. Ackers... and sold by the Author..., 2nd ed., 1735)

PRICE, FRANCIS, *A Series of Particular and Useful Observations, made with Great Diligence and Care, upon that Admirable Structure, the Cathedral Church of Salisbury* (London: Printed by C. and J. Ackers..., 1753)

PRIOR, E.S., *A History of Gothic Art in England* (London: Bell, 1900)

PRIOR, E. S., *An Account of Medieval Figure-sculpture in England* (Cambridge: CUP, 1912)

PUGIN, AUGUSTUS, *et al.*, *Examples of Gothic Architecture,* 3 Vols. (London: Printed for the executors of the late Augustus Pugin, and Augustus Welby Pugin, 1836-40)

PUGIN, A. W. N, *Contrasts, or a parallel between the noble edifices of the fourteenth and fifteenth centuries and similar buildings of the present day; shewing the present decay of taste* (London: 1836)

PUGIN, A. W. N., *The True Principles of Pointed or Christian Architecture* (London: JohnWeale, 1841)

QUINEY, ANTHONY, 'Hall or Chamber? That Is the Question. The Use of Rooms in Post-Conquest Houses', *Architectural History* , Vol. 42, (1999), pp. 24-46

RACKHAM, OLIVER, 'The Oak Tree in Historic Times', in Morris and Perring (eds.), 1974, pp. 62-79.

RACKHAM, OLIVER, *Trees and Woodland in the British Landscape* (London: Phoenix, 2001)

RACKHAM, OLIVER, *Ancient Woodland: Its History, Vegetation and Uses in England* (Dalbeattie: Castlepoint, new ed., 2003)

RANDALL, G., *The English Parish Church* (London: Batsford, 1982)

REDSTONE, V. B., *Ipswich Borough (Corporation) Records* (Ipswich: 1926-39)

REDSTONE, L. J., *Ipswich Through the Ages* (Ipswich: 1969)

REILLY, LISA A., *An Architectural History of Peterborough Cathedral* (Oxford: Clarendon Press, 1997)

RICKERT, EDITH, *Chaucer's World*, eds. Clair C. Olson and Martin D. Crow (New York: Columbia University Press, 1948)

RICKMAN, THOMAS, *An Attempt To Discriminate The Styles Of Architecture From The Conquest To The Reformation* (London: Longman, Hurst, Rees, Orme, & Brown 1817)

RIGBY, S. H. (ed.), *A Companion to Britain in the Later Middle Ages* (London: Blackwell, 2008)

RIGOLD, S. E., 'Fourteenth-century Halls in the East Weald', *Archaeol. Cantiana* (1967), 241-62.

ROBERTSON, KELLIE; UEBEL, MICHAEL (eds.), *The Middle Ages at Work: Practicing Labor in Late Medieval England* (New York; Basingstoke: Palgrave Macmillan, 2004)

ROBERTS, E., 'Moulding Analysis and Architectural Research: The Late Middle Ages', *Architectural History* 20 (1977), 5-13.

ROBERTS, EDWARD, 'William of Wykeham's House at East Meon, Hants', *Archaeological Journal* 150 (1993), pp. 456-481.

ROBERTS, EDWARD, *Hampshire Houses 1250-1700* (Hampshire County Council, 2003)

ROBISON, JOHN [also F. Price and T. Tredgold], *A Rudimentary Treatise on the Principles of Construction in the Carpentry and Joinery of Roofs* (London: 1859)

ROBISON, JOHN, TREDGOLD, THOMAS, *A Rudimentary Treatise on the Principles of Construction in the Carpentry and Joinery of Roofs* (London, John Weale, 1859)

RODWELL, W., *English Heritage Book of Church Archaeology* (London: Batsford, 1989)

RODWELL, W., *The Archaeology of Churches* (Stroud: Tempus, 2005)

ROGAN, JOHN, (ed.) *Bristol Cathedral: History & Architecture* (Stroud: Tempus 2000)

RONDELET, JEAN-BAPTISTE, *Traité de l'art de bâtir* (Paris: 1830-32)

ROSE, WALTER, *The Village Carpenter* (Hertford: Stobart Davies, 2001)

ROSKELL, J. S., *The House of Commons 1386-1421*, Vol. 1, *Introductory Survey, Appendices, Constituencies* (Stroud: Published for the History of Parliament Trust by Alan Sutton, 1992)

ROSS, W. O. (ed.), *Middle English Sermons* (Oxford: OUP & EETS, 1940

ROSS, PETER; METTEM, CHRISTOPHER; HOLLOWAY, ANDREW, *Green Oak in Construction* (High Wycombe: TRADA: 2007)

ROSSER, GERVASE, *Medieval Westminster 1200-1540* (Oxford: Clarendon Press, 1989)

ROSSER, GERVASE, 'Crafts, Guilds, and the Negotiation of Work in the Medieval Town', *Past and Present* 154 (1997), pp. 3-31

ROYAL COMMISSION ON HISTORICAL MONUMENTS, *An Inventory of the Historical Monuments …* [multiple regional and metropolitan volumes] (London: H.M.S.O.)

RUDOLPH, CONRAD (ed.), *A Companion to Medieval Art* (Oxford: Blackwell, 2006)

RUSHFORTH, GORDON MCNEIL, *Medieval Christian Imagery, as illustrated by the painted windows of Great Malvern Priory Church, Worcestershire* (Oxford: The Clarendon Press, 1936)

ST JOHN HOPE, W. H. *Windsor Castle, an Architectural History*, 2 Vols. (London: Country Life, 1913)

SACKVILLE-WEST, V, *English Country Houses* (London: Collins, 1941)

SALTER, ELIZABETH, 'A Complaint against Blacksmiths', *Literary History* 5 (1979), pp. 194-215.

SALZMAN, *English Industries of the Middle Ages* (Oxford: Clarendon Press, new ed., 1923)

SALZMAN, L. F., *English Trade in the Middle Ages* (Oxford: Clarendon press, 1931)

SALZMAN, L. F., *Building in England Down to 1540* (Oxford, OUP, 1952)

SANDFORD, JOHN HAMILTON, *A Description of St. Mary's Church, Bury St. Edmunds* (Gloucester: British Publishing Co., 10th ed., 1962)

SAUL, NIGEL, 'Richard II, York, and the Evidence from the King's Itinerary', in Gillespie (ed.), 1997, pp. 71-92

SAUL, NIGEL, *Richard II* (New Haven; London: Yale University Press, 1997)

SAUL, NIGEL, 'The Kingship of Richard II', in Goodman & Gillespie (eds.), 1999, pp. 37-58

SAUL, NIGEL, *English Church Monuments in the Middle Ages: History and Representation* (Oxford: Oxford University Press, 2009)

SAUL, NIGEL; TATTON-BROWN, T. W. T. (eds.), *St. George's Chapel, Windsor: History and Heritage* (Stanbridge: Dovecote Press 2010)

SAUNDERS, HILARY ST GEORGE, *Westminster Hall* (London: Michael Joseph, 1951)

SCATTERGOOD, V. J.; SHERBOURNE, J. W. (eds.), *English Court Culture in the Later Middle Ages* (London: Duckworth, 1983)

SCHAPIRO, MEYER, 'On the Aesthetic Attitude in Romanesque Art', in *Romanesque Art: Selected Papers*, (New York: George Braziller, 1977)

SCHELLER, ROBERT W., *Exemplum: Model Book Drawings and the Practice of Artistic Transmission in the Middle Ages (ca. 900 – ca. 1470)*, trans. Michael Hoyle, (Amsterdam: Amsterdam University Press, 1995)

SCHOFIELD, JOHN: *The Building of London: from the Conquest to the Great Fire* (London: British Museum Publications in association with The Museum of London, 1984)

SCHOFIELD, JOHN, *Medieval London Houses* (New Haven; London: Yale University Press for the Paul Mellon Centre for Studies in British Art, 1994)

SCOTT, SIR GEORGE GILBERT, *Gleanings From Westminster Abbey* (Oxford: Henry & Parker, 1863)

SCOTT, SIR GEORGE GILBERT, *Personal and Professional Recollections*, (Sampson low Marston Searle & Rivington, 1879)

SCOTT, ROBERT A., *The Gothic Enterprise* (Berkeley and London: University of California Press, 2003)

SELLAR, W. D. H. (ed.), *Moray: Province and People* (Edinburgh: Scottish Society for Northern Studies, 1993)

SHANKS, J. D., WALKER, P., 'Experimental Performance of Mortice and Tenon Connections in Green Oak' *The Structural Engineer* Vol. 83 (2005), Issue 17: p. 40-45.

SHELBY, L. R., 'The Education of Medieval Masons', *Medieval Studies* 32 (1970), pp. 1-26.

SHELBY, L. R., *Gothic Design Techniques: the Fifteenth-century Design Booklets of Mathes Roriczer and Hanns Schmuttermayer*. (Carbondale: Southern Illinois University Press, 1977).

SHELBY, L. R., 'The Geometric Knowledge of Medieval Master Masons', *Speculum* 47 (1972), pp. 395-421.

SIMPSON, ALFRED E., *History of Mildenhall* (Mildenhall: S. R. Simpson, 3rd ed., 1901)

SINGER, CHARLES, *et al.*, *A History of Technology,* 5 Vols. (New York and London: Oxford University Press, 1954–1958)

SKINNER, FREDERIC GEORGE, *Weights and Measures: their Ancient Origins and their Development in Great Britain up to AD 1855* (London: HMSO, 1967)

SLOCOMBE, PAMELA, *Medieval houses of Wiltshire* (Stroud, Gloucestershire: Sutton, 1992)

SMIRKE, SIDNEY, ‘Remarks on the Architectural History of Westminster Hall’, *Archaeologia* XXVI (1836), pp. 406-421.

SMIRKE, SIDNEY, ‘A Further Account of the Original Architecture of Westminster Hall’, *Archaeologia* XXVII, (1938), pp. 135-9.

SMITH, D., *Old Furniture and Woodwork* (London: Batsford, 1949)

SMITH, ELIZABETH BRADFORD; WOLFE, MICHAEL (eds.), *Technology and Resource Use in Medieval Europe: Cathedrals Mills and Mines* (Aldershot: Ashgate, 1997)

SMITH, JAMES, *The Carpenters Companion: being an accurate and compleat treatise of carpenters works; ... exemplified in forty-one copper-plates …* (London: printed for J. Millan, 1733)

SMITH, JAMES, *A Specimen of Antient Carpentry: Consisting of Variety of Designs for Roofs …* (London: printed for the author, 1736)

SMITH, J. T., ‘Medieval Aisled Halls and their Derivatives’, *Archaeological Journal CXII* (1955), pp. 76-94.

SMITH, J. T., ‘Stokesay Castle’, *Archaeological Journal* 113 (1956), pp. 211-14.

SMITH, J. T., ‘Medieval Roofs: A Classification’, *Archaeological Journal*, Vol. 115, 1958, p. 111-149.

SMITH, J. T., ‘Timber-framed Building in England: its Development and Regional Differences’, *Archaeological Journal*, Vol. 122, (1965), p. 58.

SMITH, J. T., ‘The Reliability of Typological Dating of Medieval English Roofs’, in Berger (ed.), 1970, pp. 239-269.

SMITH, J. T., ‘The Early Development of Timber Buildings’, *Archaeological Journal*, Vol. 131 (1974), pp. 238-63.

SMITH, J. T., *et al.*, *Studies in Medieval Domestic Architecture* (London: Royal Archaeological Institute, 1975)

SMITH, J. T., Untitled review: *English Cathedral Carpentry* by C. A. Hewett, *The Art Bulletin,* Vol. 60, No. 2 (Jun., 1978), pp. 365-366

SMITH, J. T., *English Houses 1200-1800: The Hertfordshire Evidence* (London: HMSO, 1992)

SMITH, JOHN THOMAS, *Antiquities of Westminster: the Old Palace; St. Stephen's Chapel* (London: printed for J. T. Smith and sold by R. Rejan and J. Manson, 1807), also, *Sixty-two additional plates to Smith's Antiquities of Westminster* (1807-09)

SMITH, P., *Houses of the Welsh Countryside: a Study in Historical Geography* (London: Her Majesty's Stationary Office, 2nd ed., 1988)

SNELL, B. S., 'Some Ancient Building Terms', *RIBA Journal*, 18 December, 1926.

SNELL, B. S. 'More Ancient Building Terms', *RIBA Journal*, 22 December 1928.

SOBON, JACK; SCHROEDER, ROGER, *Timber Frame Construction* (North Adams, Mass.: Storey Books, 1984)

STEEL, ANTHONY, *Richard II* (Cambridge: Cambridge University Press, 1941)

STELL, GEOFFREY; BAILLIE, MICHAEL, 'The Great Hall and Roof of Darnaway Castle, Moray', in Sellar (ed.), 1993, pp. 163-86.

STENNING, D. F., 'The Roof at Dartington Hall', *Vernacular Architecture* 29 (1998), pp. 93-97.

STEWART, DAVID JAMES, *On the Architectural History of Ely Cathedral* (London: 1868)

STONE, LAWRENCE, *Sculpture in Britain: The Middle Ages* (Harmondsworth: Penguin, 2nd ed., 1972)

STUART, ROBERT, *A Dictionary of Architecture: historical, descriptive, topographical, decorative, theoretical, and mechanical, alphabetically arranged, familiarly explained, and adapted to the comprehension of workmen* (London: Jones & Co. 1825)

STRAUB, HANS, *A History of Civil Engineering* (London: Leonard Hill, 1952)

STREET, GEORGE EDMUND, 'On English Woodwork in the Thirteenth and Fourteenth Centuries', *RIBA Transactions,* 1st series, Vol. 14, 1864/1865, pp. 85-108

STRICKLAND, DEBRA HIGGS, *Saracens, Demons, and Jews: Making Monsters in Medieval Art* (Princeton, N.J.; Oxford: Princeton University Press, 2003)

STRZYGOWSKI, JOSEF, *Early Church Art in Northern Europe* (London: Batsford, 1928)

SUMMERSON, JOHN (ed.) *Concerning Architecture: Essays on Architectural Writers and Writing Presented to Nikolaus Pevsner* (London: Allen Lane, 1968)

SUNLEY, JOHN; BEDDING, BARBARA (eds.), *Timber in Construction* (London: Batsford / Trada, 1985)

SWANSON, H, *Medieval Artisans: The Urban Class in Late Medieval England* (Oxford: Basil Blackwell, 1989)

SWANSON, ROBERT N., *Church and Society in Late Medieval England* (London: Blackwell, 1989)

SWANSON, ROBERT N., *Catholic England: Faith, Religion and Observance Before the Reformation* (Manchester: Manchester University Press, 1993)

SWANSON, ROBERT N., *Religion and Devotion in Europe* (Cambridge: Cambridge University Press, 1995)

SWEETINBURGH, SHEILA (ed.), *Later Medieval Kent* (Woodbridge: Boydell Press; Kent County Council, 2010)

TANNER, LAWRENCE E. 'Westminster School', *Country Life*, Vol. 74, 1933 Dec. 2, p. 587-594.

TANNER, LAWRENCE E., 'Dean's Yard and the Precincts of Westminster Abbey', *London Society Journal,* 1959, Nov., p. 46-51,

TANNER, NORMAN P., *Heresy Trials in the Diocese of Norwich, 1428-31* (London: Royal Historical Society, 1977)

TANNER, NORMAN P., *The Church in Late Medieval Norwich* (Toronto: Pontifical Institute of Mediaeval Studies, 1984)

TARN, E. WYNDHAM, *An Elementary Treatise on the Construction of Roofs of Wood and Iron* (London: Crosby, Lockwood & Co., 1882)

TATTON-BROWN, TIM, 'Building the Tower and Spire of Salisbury Cathedral', *Antiquity* 65 (1991), pp. 74-96.

TATTON-BROWN, TIM, 'The Buildings of the Bishop's Palace and the Close', in Hobbs (ed.), 1994, pp. 225-246.

TATTON-BROWN, TIM, 'The Medieval Fabric', in Hobbs (ed.), 1994, pp. 25-46.

TATTON-BROWN, TIM, 'The Archaeology of the Spire at Salisbury Cathedral', in Keen & Cocke (eds.), 1996, pp. 59-67.

TATTON-BROWN, TIM; MUNBY, JULIAN (eds.) *The Archaeology of Cathedrals* (Oxford: Oxford University School of Archaeology, 1996)

TAYLOR, HENRY, 'Ightham Mote', *Archaeologia Cantiana*, 27 (1905), pp. 1-29.

THOMAS, CHRISTOPHER; COWIE, ROBERT; & SIDELL, JANE, *The Royal Palace, Abbey and Town of Westminster on Thorney Island* (London: Museum of London Archaeology Service, 2006)

THOMPSON, A. H., *The Cathedral Churches of England* (London: SPCK, 1925)

THOMPSON, J. A. F., *Later Lollards* (London: Oxford University Press, 1965)

THOMPSON, M. W., *The Medieval Hall* (Aldershot: Scolar Press, 1995)

THOMPSON, M. W., *Medieval Bishops' Houses in England and Wales* (Aldershot: Ashgate, 1998)

THORNES, R.; FRADGLEY, N., 'Upton Court, Slough: An Early Fourteenth-Century Open Hall', *Archaeological Journal,* Vol. 145 (1988), pp. 211-221.

TIERNEY, REV. MARK ALOYSIUS, *The History and Antiquities of the Castle and Town of Arundel* (London: G. and W. Nicol, 1834)

TIPPING, H. AVRAY, *English Homes*, *Mediaeval and early Tudor 1066-1558* (London: Country Life, 1937)

TOBY MORRIS, E; BLACK, R. GARY; TOBRINER, STEPHEN O., 'Report on the Application of Finite Element Analysis to Historic Structures: Westminster Hall, London', *Journal of the Society of Architectural Historians,* Vol. 54, No. 3 (Sep., 1995), pp. 336-347

TOLHURST, J. B. L., 'The Hammer-beam Figures of the Nave Roof of St. Mary's Church, Bury St Edmunds', *Journal of the British Archaeological Association*, Series 3, Vol. 25 (1962), pp. 66-70.

TOPHAM, JOHN, *An Account of the Collegiate Church of St Stephen…* (Simpkin, & Marshall, 1834)

TRACY, CHARLES, *English Gothic Choir-stalls, 1200-1400* (Woodbridge: The Boydell Press, 1987)

TRACY, CHARLES, *English Medieval Furniture and Woodwork* (London: Victoria and Albert Museum, 1988)

Transactions of the Shropshire Archaeological and Historical Society (Shrewsbury 1989-)

TREDGOLD, THOMAS, *Elementary Principles of Carpentry …* (London: J. Taylor, 2nd ed., 1828; 3rd ed., 1840)

TREDGOLD, T; BARLOW, P., *Elementary Principles of Carpentry* (London: John Weale, 4th ed., 1853)

TUCK, J. A., 'Richard II's System of Patronage', in Du Boulay & Barron (eds.), 1971, pp. 1-20.

TURNER, THOMAS HUDSON, *Some Account of Domestic Architecture in England*, Vol. I: *from the conquest to the end of the thirteenth century* (Oxford: Parker, 1851)

TURNER, THACKERAY, *Remarks on the Proposed Restoration of Westminster Hall,* (London: 1885)

TWOPENNY, WILLIAM, *Specimens of Ancient Woodwork* (London: 1859)

TYMMS, SAMUEL, *An Architectural and Historical Account of the Church of St. Mary, Bury St. Edmunds* (Bury St Edmunds: 1845-54)

ULRICH, R. B., *Roman Woodworking* (London: Yale University Press, 2007)

UNGER, RICHARD W., *The Art of Medieval Technology: Images of Noah the Shipbuilder* (New Brunswick, N.J.: Rutgers University Press, 1991)

VALLANCE, AYMER, *The Old Colleges of Oxford* (London: Batsford, 1912)

VALLANCE, AYMER, *English Church Screens: being great roods, screenwork & rood-lofts of parish churches in England & Wales* (London: Batsford, 1936)

VALLANCE, AYMER, *Greater English Church Screens, being great roods, screenwork & rood-lofts in cathedral, monastic & collegiate churches in England & Wales* (London, New York: B.T. Batsford, 1947)

Victoria County History, various county volumes (1923-)

VIOLLET-LE-DUC, EUGÈNE-EMMANUEL, *Dictionnaire raisonné de l'architecture Française du X1e. au Xvie. Siècle* (Paris: 1854-58)

VIOLLET-LE-DUC, EUGÈNE-EMMANUEL, *Discourses on Architecture*, trans. Henry Van Brunt (Boston: 1875)

VITRUVIUS, *The Ten Books on Architecture* (New York: Dover, 1960)

WADDELL, GENE, 'The Design of the Westminster Hall Roof', *Architectural History*, Vol. 42 (1999), pp. 47-67.

WADE-MARTINS, PETER (ed.) *An Historical Atlas of Norfolk* (Norwich: Norfolk Museums Service in association with the Federation of Norfolk Historical and Archaeological Organisations, 1994)

WALKER, JOHN, 'Tiptofts, Wimbish, Essex: Report of Architectural Survey' (2008, unpublished as of March, 2014)

WALKER, JOHN (ed.), *The English Medieval Roof: Crownpost to Kingpost* (Essex Historic Buildings Group, 2011)

WALKER, PHILIP, 'The Tools Available to the Medieval Woodworker', *British Archaeological Reports, Intl Ser.*, 129, 1982, pp. 349-56.

WARE, ISAAC, *The Four Books of Andrea Palladio's Architecture* (London: 1737)

WEBB, G. F. *Architecture in Britain: The Middle Ages* (Harmondsworth: Penguin, 2nd ed., 1965)

WEBSTER, CHRISTOPHER (ed.), *Episodes in the Gothic Revival: Six Church Architects* (Reading: Spire, 2011)

WELANDER, DAVID, *The History, Art and Architecture of Gloucester Cathedral* (Stroud: Alan Sutton, 1991)

WESTON, D. W. V., *Carlisle Cathedral History* (Carlisle: Bookcase, 2000)

WHEELER, W. H., *A History of the Fens of South Lincolnshire* (Stamford: P. Watkins, 1990)

WHITE, JAMES F., *The Cambridge Movement: The Ecclesiologists and the Gothic Revival* (Cambridge: University Press, 1962)

WHITE, LYNN, 'Medieval Engineering and the Sociology of Knowledge', *Medieval Religion and Technology, Collected Essays* (Berkeley: UCA Press, 1978), pp. 317-338.

WHITE, LYNN, *Medieval Religion and Technology* (Berkeley / London: University of California Press, 1978)

WHITE, LYNN, *Medieval Technology and Social Change* (London: Oxford University Press, 1962)

WHITING, BARTLETT JERE, *Proverbs, Sentences, and Proverbial Phrases from English Writings Mainly Before 1500* (London: Oxford University Press, 1968)

WHITNEY, ELSPETH, *Paradise Restored: the Mechanical Arts from Antiquity through the Thirteenth Century* (Philadelphia: American Philosophical Society, 1990)

WILKS, J. H., *Trees of the British Isles in History and Legend* (London: Frederick Muller, 1972)

WILLIAMS, DAVID, *Deformed Discourse: The Function of the Monster in Mediaeval Thought and Literature* (Exeter: University of Exeter Press, 1996)

WILLIAMS, G. A., *Medieval London: from Commune to Capital* (London: Athlone Press, 1970)

WILLIAMS, J. F., 'The Black Book of Swaffham', *Norfolk Archaeology* 33 (1962-65), pp. 243-53.

WILLIAMS, WILLIAM MORGAN, *The Country Craftsman: a Study of some Rural Crafts and the Rural Industries Organisation in England* (London: Routledge & Kegan Paul, 1958)

WILLIAMSON, W. W., 'Saints on Norfolk Rood Screens and Pulpits', *Norfolk Archaeology* 31 (1955-57), pp. 299-346

WILLINS, EDWARD PRESTON, *Some of the Old Halls and Manor-Houses in the County of Norfolk* (London: Jarrold & Sons, 1890)

WILLIS, ROBERT, *Architectural History of Canterbury Cathedral* (London: 1845)

WILLIS, ROBERT, 'Construction of Medieval Vaults …', *RIBA Transactions,* Vol. I (1842), pt. 2, pp. 1-69.

WILLIS, ROBERT, *The Architectural History of Chichester Cathedral* (Chichester: 1861)

WILLIS, ROBERT, *Architectural History of Some English Cathedrals* (Chicheley: Paul P. B. Minet, 1973)

WILSON, CHRISTOPHER, 'The Original Design of the City of London Guildhall', *Journal of British Archaeological Association*, 3rd series, Vol. 129 (1976), pp. 1-14.

WILSON, CHRISTOPHER, *The Gothic Cathedral* (London, Thames & Hudson, 1990)

WILSON, CHRISTOPHER, 'Rulers, Artificers and Shoppers: Richard II's Remodelling of Westminster Hall, 1393-99', in Gordon, Monnas & Elam (eds.), 1997, pp. 33-59.

WILSON, CHRISTOPHER, 'The Royal Lodgings of Edward III at Windsor Castle', in Keen & Scarff (eds.), 2002, pp. 15-94.

WILSON, PETER LAMBORN, *Angels* (London: Thames and Hudson, 1980)

WOOD, MARGARET, 'Norman Domestic Architecture', *Archaeological J.*, 92 (1935), pp. 167-242

WOOD, MARGARET, *The English Medieval House* (London: Bracken Books, 1983)

WOOD, JASON (ed.), *Buildings Archaeology: Applications in Practice* (Oxford: Oxbow Books, 1994)

WOODMAN, FRANCIS, *The Architectural History of Canterbury Cathedral* (London: Routledge & Kegan Paul, 1981)

WOODMAN, FRANCIS, 'Hadley, Norfolk, and the Rebuilding of its Chancel', in Buckton & Heslop (eds.), (1994), pp. 203-10

WORMALD, F., *English Drawings of the Tenth and Eleventh Centuries* (London: Faber, 1952)

WORMALD, F. (ed.), *The Winchester Psalter* (London: Harvey Miller & Medcalf 1973)

WYATT, T. H., 'On the Old Hall and New Assize Courts at Winchester', *RIBA Proceedings*, 1873-4, pp. 157-169.

YEOMANS, DAVID, 'Medieval Roof Structures: a Survey of the Available Literature on Timber Roof Construction', *AAQ*, Vol. 7 (1975), no. 2, Apr./June, p. 42-50

YEOMANS, DAVID, 'Historic Development of Timber Structures', in Sunley and Bedding (eds.),1985, pp. 62-84.

YEOMANS, DAVID, 'Early Carpenters' Manuals 1592-1820,' *Construction History,* Vol. 2 (1986), pp. 13-33.

YEOMANS, DAVID, 'Three Timber Roofs', *Assoc. for Studies in the Conservation of Historic Buildings. Trans.*, Vol. 16 (1991), pp. 52-58.

YEOMANS, DAVID, 'The Architect and the Carpenter', *RIBA Journal,* Vol. 99, no. 4, (1992), Apr., p. 26-29.

YEOMANS, DAVID., *The Trussed Roof: Its History and Development* (Aldershot: Scholar press, 1992)

YEOMANS, DAVID, (ed.),*The Development of Timber as a Structural Material* (Aldershot: Ashgate, 1999)

YEOMANS, DAVID, *The Repair of Historic Timber Structures* (London: Thomas Telford, 2003)

YEOMANS, DAVID, *How Structures Work: Design and Behaviour from Bridges to Buildings* (Oxford: Wiley-Blackwell, 2009)

YUN SHENG HUANG; MARK, ROBERT; WELLMAN, AVERY M., 'Westminster Hall's Hammer-Beam Roof: A Technological Reconstruction', *APT Bulletin,* Vol. 20, No. 1 (1988), pp. 8-16.

ZENNER, MARIE-THERESE (ed.) *Villard's Legacy: Studies in Medieval Technology, Science and Art in Memory of Jean Gimpel* (Aldershot: Ashgate, 2004)

ZUPKO, RONALD EDWARD, *British Weights & Measures: a History from Antiquity to the Seventeenth Century* (Madison; London: University of Wisconsin Press, 1977)

ZUKOWSKY, JOHN, untitled review of *English Cathedral Carpentry* by Cecil Hewett in *Journal of the Society of Architectural Historians* Vol. 35, No. 2 (May, 1976), pp. 140-141.

ZWERGER, KLAUS, *Wood and Wood Joints: Building Traditions of Europe and Japan* (Basel: Birkhauser, 1997)