An Overlooked Source of Influence for the Fan Vaulting of the Chapel of Henry VII at Westminster Abbey

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The vaults of the Divinity School and Christ Church Cathedral at Oxford are generally regarded as the prototypes for the vaulting of the Chapel of Henry VII at Westminster Abbey. While undoubtedly influenced by the vaults, the design of the fan vaulting in the Chapel appears to have another, overlooked source of inspiration. A marked similarity in conception exists between the vaulting of the Chapel and the hammerbeam roof of the Great Hall at Westminster Palace. That becomes apparent in the comparison of the cross-sections of the two structures (Figures 1-2), though I have found no reference which makes an association between them. Pevsner suggests that the use of strong transverse arches, cusping and tracery in the spandrels of the arches at the Chapel are derived from timberwork but goes no further.[1]

The basic designs of the hammerbeam roof and the masonry vault are essentially related, and their differences can be explained by the inherent disparity of their materials. Therefore, it seems possible, and even likely, given their proximity, that the timber roof may have suggested the solution to the problem of successfully combining the fan vault with the pendant vault, accomplished at the Chapel of Henry VII, 1503-09. That solution was sought but not quite successfully achieved by William Orchard at the Divinity School, 1480-83, and Christ Church Cathedral, 1500. Additionally, if in fact the design of the timber roof suggested the design of the masonry vault, then there occurred at London a productive fusion of the accomplishments of East Anglican timberwork and West Country masonry vaulting.

If the basic structural elements of the design of the timber roof at Westminster Hall, that is, the transverse arches, the arch braces and the vertical strut, or hammer posts, were rendered in stone, the result would be essentially the underpinning structure of the Chapel. It would be possible then to superimpose upon that structure the unique system of fan vaulting found in the Chapel. The very nature of executing those forms in stone would eliminate the need for the supporting hammerbeam itself, and therefore, free the vertical strut, now a suspended voussoir-pendant, to serve as the springing for the fan vault.[2] In seeking prototypes for the design of the vault at Henry VII's Chapel, the tendency appears to have been to seek the obvious, that is any structure the vault of which relies on pendants for its springing. In fact, the roof of Westminster Hall, in its medium, provides the framework for just that.

The most readily apparent similarity between the vault of Henry VII's Chapel (Figure 3) and the hammerbeam roof of Westminster Hall (Figure 4) is their common use of prominent transverse arches. A remarkable structural as well as aesthetic feat, the vault of the Chapel is actually a combination of interpenetrating fan and pendant vaults in which the transverse arches pass through the independent shell structure created by the fans (Figure 5). The transverse arches support the eight foot pendants which are, in fact, elongated voussoirs, the wedged building blocks of the arch itself. The pendants, in turn, support 360° conoids which, together with connecting spandrels, constitute the fan vaulting. While the transverse arches at Westminster Hall are totally exposed, there being no fan vault superimposed upon them, those at the Chapel are hidden above the shell structure for the center two-thirds of the vault.

A fan vault is composed of inverted conoids, or cones, which are generated by the revolution of an arc around its vertical axis (Figure 6). The conoid consists of ribs of the same curvature, spaced at equal angles and bounded by a horizontal circular rib.[3] All horizontal sections of the conoid are segments of circles, or sections into which circles can be inscribed.[4] Were the vertical strut at Westminster Hall to become the vertical axis of a fan conoid, the arch brace which begins at its base to be revolved around the vertical strut, according to the definition of a fan conoid, and the hammerbeam itself removed, then the design of the Great Hall would be very close to that of the Chapel. The hypothetically suspended fans would then create a curved shell structure independent of the central section of the transverse arch, much as it is found at the Chapel of Henry VII. The change of building material from timber to stone would enable such a transformation of the design.

The principal differences between the construction of the hammerbeam roof of Westminster Hall and the masonry vault of the Chapel relate to the differences in the properties of the material used. The vertical strut of the hammerbeam roof occupies a comparable position to that of the stone pendant. However, the two function antithetically because of the differing constructional properties of the materials. While the vertical strut of the timber roof is supported by the hammerbeam, its counterpart in stone is suspended from its transverse arch because the masonry arch is, to the extent that it is properly constructed, a self-supporting composite of wedged voussoirs, or stones, eliminating the need for support from below. By executing the design of the timber roof in masonry and eliminating those features necessitated only by timber construction, the design of Westminster Hall would yield the underlying design of Henry VII's Chapel.

While the vaults of the Divinity School (Figure 7) and Christ Church Cathedral (Figure 8) are more immediately obvious prototypes for the vaulting of the Chapel, in some respects their designs are not as close to that of the Chapel as the hammerbeam roof of the Great Hall. The vaults of both these buildings are pendant vaults combined with lierne vaults, a related but altogether

different concept from fan vaulting. While lierne vaulting is conceived in linear terms, fan vaulting is conceived in terms of solid geometric forms which are necessary to create an independent shell structure such as that at the Chapel. The design of the vault at Christ Church Cathedral more nearly approaches the design of Henry VII's Chapel, than does that of the Divinity School. Its transverse arches become lost behind the central lierne work and its more greatly extended pendants support rib patterns more suggestive of fans. The transverse arches of the Divinity School, by contrast, remain fully exposed and support short pendants, and are, therefore, less convincingly integrated into the vault design. The most striking feature common to the three masonry vaults, however, in addition to their use of strong transverse arches, is their use of a pair of pendants suspended a distance from the side walls. A pair of pendants is suggested also in the design of the roof of Westminster Hall, although allowing for the inherent structural characteristics of timber, the pendants are represented as a pair of vertical struts resting on hammerbeams.

The adaptation of timber constructional forms to masonry construction was not unprecedented during the Gothic period. Walter Horn suggests that the concept of the medieval bay system used in Gothic masonry construction had its origins in constructional forms logical to timber but unnatural to stone construction.[5] Jean Bony cites the vaulting of the aisles of Bristol Cathedral, circa 1311-30, as an example of timber constructional forms rendered in stone.[6] He states that "it was part of the refinements of Court art to translate forms from one material into another," giving further support to the likelihood that the timberwork at Westminster Hall may have influenced the stonework at the Chapel of Henry VII.[7]

Fifteenth-century masons appear to have been cautious about spanning significant distances with masonry fan vaults and it appears that experimental designs were often first executed in timber, especially when greater spans were to be covered. The earliest fan vaults, excluding minor tomb canopies and small chantries, are found at the cloisters of Gloucester Cathedral, begun between 1351 and 1377 and completed by 1412, which span a mere twelve feet. Fan vaults of significant width and height were not constructed in stone until the second half of the fifteenth century. Interestingly enough, the first high vault of fan construction of considerable span was executed in timber at Winchester College Chapel between 1395 and 1400, attributed to Hugh Herland, the master carpenter and designer of the hammerbeam roof at Westminster Hall, which was built almost simultaneously between 1393 and 1398.

The vault of Henry VII's Chapel was built a century later, between 1503 and 1509, probably by Robert Janyns, although older scholarship has attributed the design erroneously to Robert or William Vertue. Each structure is considered the supreme achievement in its medium. John Harvey described the timberwork at Westminster Hall as the most splendid of all timber construction.[8] Francis Bond described Henry VII's Chapel as "the most wonderful work of masonry ever put together by the hand of man."[9] It seems probable that the earlier timber masterpiece inspired the later stone masterpiece, not only because of its renown and proximity, but primarily because of the visual resemblance of the two designs.

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1 Nikolaus Pevsner and Priscilla Metcalf, *The Cathedrals of England,* 2 vols. (New York: Viking Penguin Inc., 1985) 2: 174.

2 The exact function of the hammerbeam within Hugh Herland's design remains much debated. For various arguments concerning the loadbearing elements of the roof, see L.T. Courtenay and Robert Mark, "The Westminster Hall Roof: A Historiographic and Structural Study," *Journal of the Society of Architectural Historians* 46 (1987) 374-395.

3 My definition of a fan conoid combines concepts derived from Willis, Howard and Leedy. Robert Willis, "On the Construction of the Vaults of the Middle Ages," *Transactions of the Royal Institute of British Architects* 1 (1842): 44, 55. Reprinted in Robert Willis, *Architectural History of Some English Cathedrals,* 2 vols. (Chicheley: Paul Minet, 1973) 2, Appendix. F. E. Howard, "Fan Vaults," *Archaeological Journal* 68 (1911): 2.

4 Walter C. Leedy, *Fan Vaulting: A Study of Form, Technology and Meaning* (Santa Monica: Arts & Architecture, 1980) 3.

5 Walter Horn, "On the Origins of the Medieval Bay System," *Journal of the Society of Architectural Historians* 17 (1958) 3.

6 Jean Bony, *The English Decorated Style: Gothic Architecture Transformed 1250-1350* (Ithaca: Cornell UP, 1979) 36.

7 Bony 22.

8 John Harvey, *The Perpendicular Style 1330-1485* (London: B.T. Batsford, 1978) 74.

9 Francis Bond, *Westminster Abbey* (London: Oxford UP, 1989) 134.

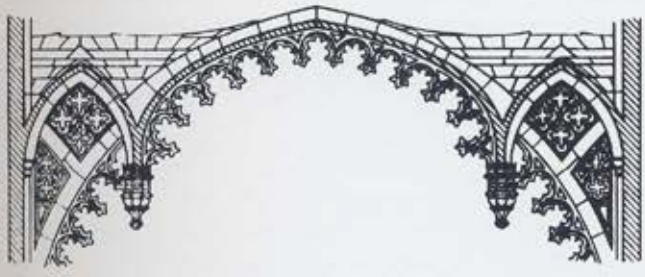

Figure 1. Cross-section, Vault of the Chapel of Henry VII, Westminster Abbey, British Crown Copyright, reproduced with the permission of the Controller of Her Majesty's Stationery Office.

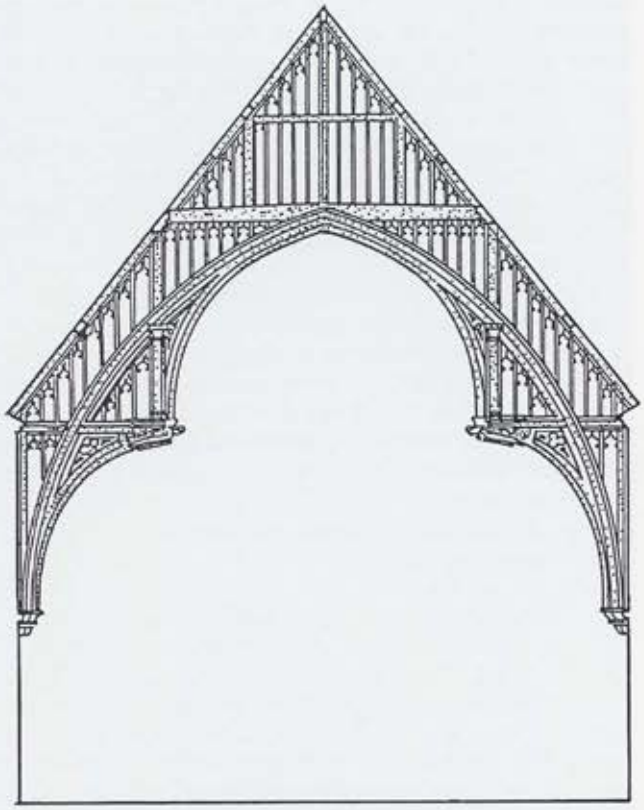

Figure 2. Cross-section, Hammerbeam Roof of the Great Hall, Westminster Palace, *Medieval Structure: The Gothic Vault,* James H. Aclund (Toronto: 1972).

Figure 4. Hammerbeam Roof, Great Hall, Westminster Palace, Courtesy of the Royal Commission on the Historical Monuments of England.

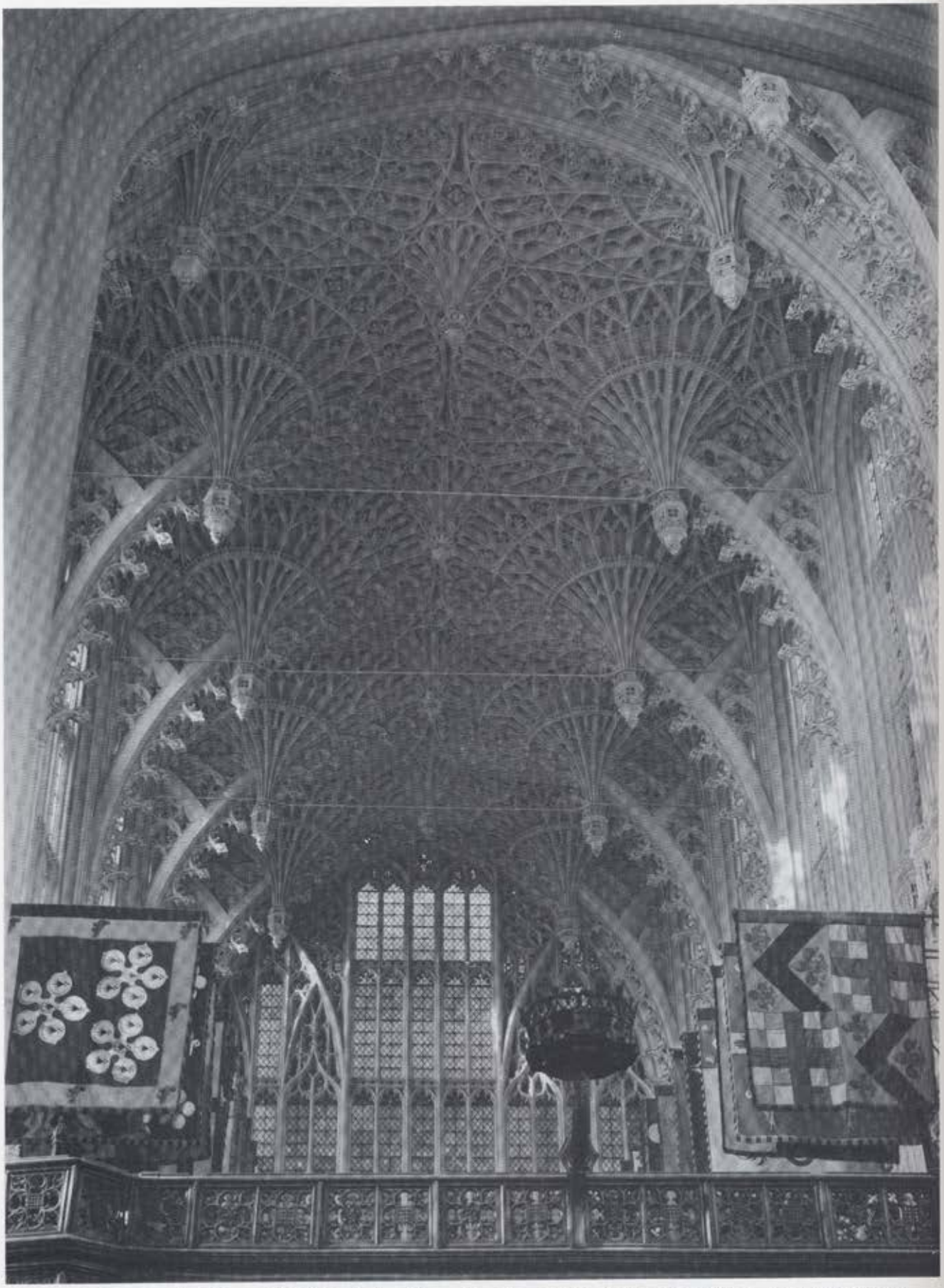

Figure 3. Vault, Chapel of Henry VII, Westminster Abbey, Courtesy of the Royal Commission on the Historical Monuments of England.

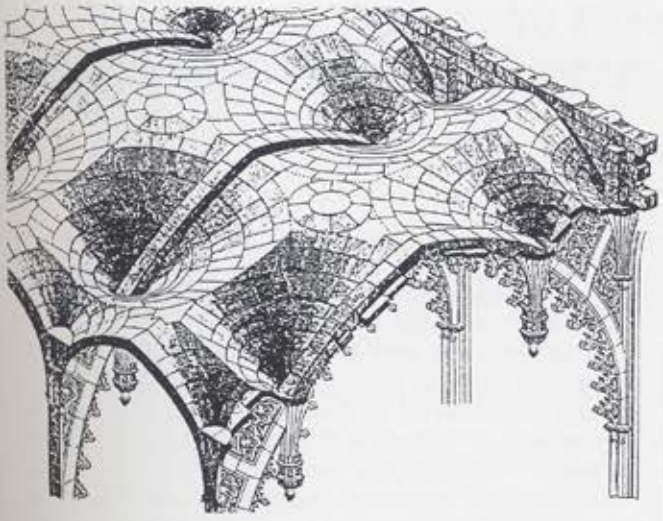

Figure 5. Isometric Drawing of the Extrados of the Vault of the Chapel of Henry VII, Westminster Abbey, drawn by Robert Willis (1842).

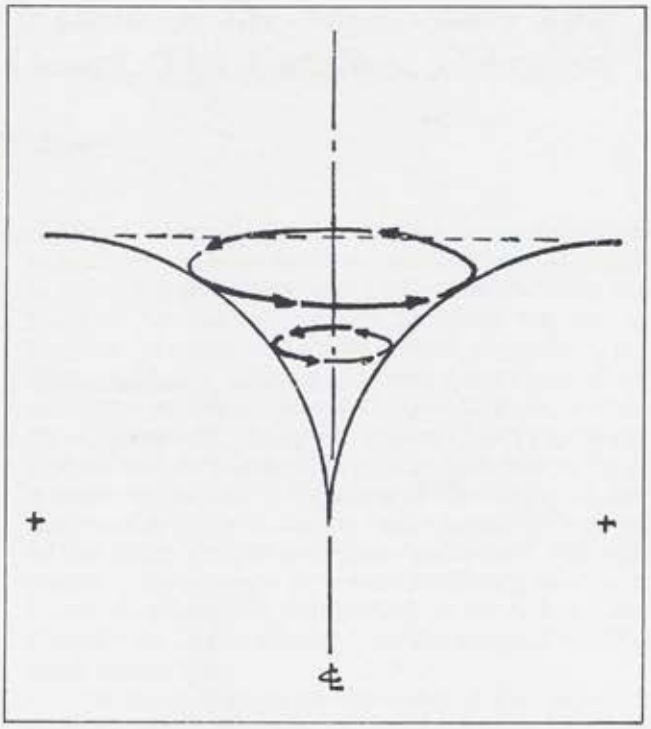

Figure 6. Drawing of a Fan Conoid. Drawn by James R. Alexander to the author's sketch.

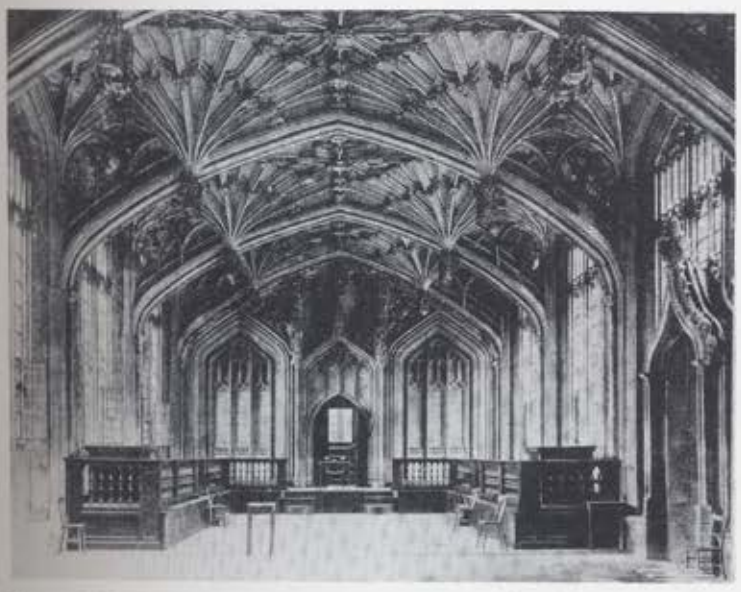

Figure 7. Vault, the Divinity School, Oxford University, *An Introduction to English Church Architecture,* Francis Bond (Oxford: 1913).

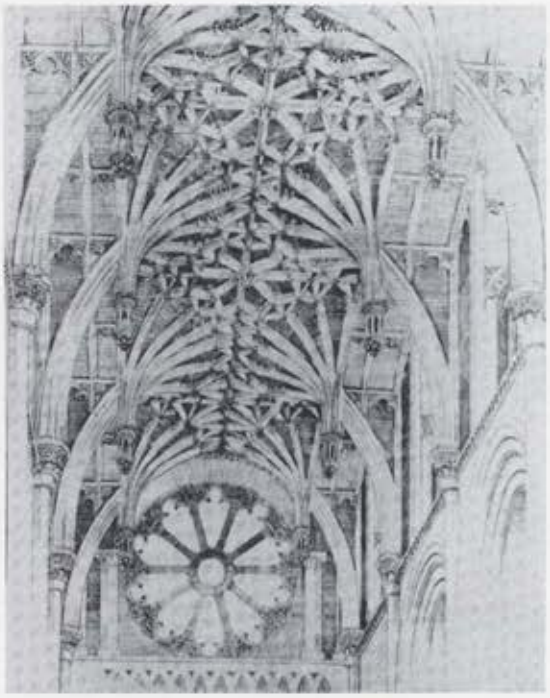

Figure 8. Vault, Christ Church Cathedral, Oxford, *An Introduction to English Church Architecture,* Francis Bond (Oxford: 1913).