Design in Gothic Architecture: A Preliminary Assessment

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Design in Gothic Architecture

A Preliminary Assessment

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"Dazu soll er alle Visierungen, die sin vatter maister Matheus säliger über das Münster und Thurn, sonder die er zu Berrn und ouch hie gemacht haut... die ouch maister Mauricius selbs gemacht haut, oder noch fürhin machen wirdt, nach seinem abgangen demselben u. l. fr. buwe... übergeben."

—Ulm, Cathedral Building Committee, contract with Moritz Ensinger, 1470[1]

THE CONCEPTS of the Gothic age are still tinged by eighteenth- and nineteenth-century romantic ideas and a lingering residue of the Protestant and Renaissance fabrication of the "Dark Ages." But to unbiassed observers, most notably architects, Gothic structures have for some time begun to reveal a sophisticated and dynamic architectural theory, and a complete design process without which much of the highly co-ordinated building procedures would have floundered. One of the reasons might lie in the realization that the lodges functioned very much like modern offices. The main reason for often sadly comical *ex cathedra* misjudgments of the Gothic architect-designer as a numerologist, as a pure pragmatist, as a groping super-mason or as a contractor-theologian lies mainly in the neglect of over 2,200 mediaeval plans and designs as well as theoretical treatises and working drawings which I had the privilege to study recently.[2] At present it seems that this grossly neglected mass of material is about one half of the documentation which will become available within the near future. As a first step, a catalogue of the 287 sheets in the Akademie der bildenden Künste in Vienna will be published by Hans Koepf.[3] Another reason for the misconceptions on Gothic design procedures has been a reluctance either to see all the material in context, or to work with contemporary master masons. On the basis of a sometimes slender but unbroken tradition, some of them still design architectural details exactly as they were conceived half a millennium ago, and will sometimes call finials "angels" or "giants," using thus even a terminology they did not invent.[4]

Much of the theoretical background presented here will not be new to American scholars who have had remarkable success in immersing themselves in the work practices of

1. Otto Kletzl, 'Plan-Fragmente aus der deutschen Dombauhütte von Prag in Stuttgart and Ulm,' *Veröffentlichungen des Archivs der Stadt Stuttgart, 3*, p. 5. "He, [Moritz Ensinger] shall make arrangements that all the plans which his deceased father master Matthew made for the minster and tower [of Ulm], Bern and here . . . and also those which Moritz himself designed and will design shall be given to the lodge of Our Lady after his death."

2. The exploration of archive material was made possible by a grant from the Guggenheim Foundation. I would also like to thank the members of the Spears Fund and University Research Committees of Princeton for help in my research. I am indebted to the M. Meiss Fund for the opportunity to undertake additional photographic work.

3. For preliminary publications see S. Freiberg and E. Hainisch, *Gotische Baurisse der Wiener Bauhütte* (Ausstellung an der Akademie der bildenden Künste, Wien, May–June 1962) and Bruno Grimschitz, *Hanns Puchspaum* (Vienna, 1947). For the works of H. Tietze, A. Macku, R. Feuchtmüller, see Freiberg and Hainisch. I would like to thank Mrs. Lhotsky, Dr. Miller of the Academy, Dr. E. Frodl, Dr. E. Bacher and Dr. M. Cykan of the Bundesdenkmalamt for their gracious help. My special thanks also go to Prof. H. Koepf, who discussed some of his findings with me previous to their publication. Due to the very large number of unpublished documents which had to be organized, I have as yet been unable to check through local publications which may contain some of the material presented here. I hope to correct possible omissions at the earliest moment.

4. My gratitude goes to Messrs. W. Weyres and A. Wolff of Cologne cathedral as well as to Messrs. Schimpf and Arnold of Strasbourg and Messrs. Pee, Lorenz, and Pohl of Ulm, without whose cooperation some of the problems discussed here would have remained unsolved.

mediaeval lodges. Beginning with Kenneth J. Conant's works on Cluny, continuing with Sumner McK. Crosby's studies on St. Denis, the imaginative work of Robert Branner and John Fitchen, together with Walter Horn's forthcoming publication of the St. Gall plan, these scholars have considerably enlarged the knowledge of mediaeval architectural practices studied earlier by men such as Viollet-le-Duc, Grimschitz, Kletzl, Hahnloser, Ueberwasser, and others.

But few of these scholars had a clear concept of the bulk of material available and of its implications for all Gothic architecture. The aim of this preliminary essay must therefore be an initial analysis of the types, purposes, and rough dates of these plans which will together eventually provide us with a complete theory of Gothic planning from 1144 to 1572.

Several important points will not be mentioned here: (1) A large number of literary sources refer not only to the existence of plans but also to the importance attributed to them. The lawsuit of the City Council of Stuttgart against Master Niclas Queck is typical. In 1497 he quit his position as Chief Master in Frankfurt to work in Mainz, and took with him a large plan for the cathedral tower which he was forced to relinquish six years later.[5] (2) I shall be unable to deal with the exceptional measured drawings. (3) One of the most important and highly complex lodge theories, the projection of vault plans into the third dimension, will have to be treated at a later date. (4) An exact comparison between the plans and the buildings executed after them is impossible within the scope of this essay. (5) Too little is as yet known about the rôle of the architectural model to treat the problem more than superficially. (6) Determination of thrust systems for which written rules existed and which seem to have been successful will have to be worked out in cooperation with structural engineers. (See R. Mark and R. A. Prentke, *Model Analysis of Gothic Structure*, in this issue.)

I nevertheless hope to ascertain that each step of Gothic construction was governed by a design and that the whole system of planning down to details was based on a highly coordinated system of geometric progression from the mid-fourteenth century onward if not earlier. It seems indeed that design procedures changed little from the Roman period to the end of the sixteenth century, and that the statement of Vitruvius found in Book I, i,4 seems completely applicable to Gothic: "An architect should be an educated man so as to be remembered by his treatises. Secondly he must have knowledge of drawing so that he can readily make sketches to show the appearance of the work he proposes. Geometry, also, is of much assistance in architecture, and in particular it teaches the use of the rule and compasses, by which we specifically acquire training in making plans for buildings in their grounds, and rightly apply the square, the level and the plummet. . . . It is true that by arithmetic the total cost of the building is calculated and measurements are computed, but difficult questions involving symmetry are solved by geometric theories and methods."[6]

5. O. Kletzl, "Planfragmente," p. 5.

THE THEORY

Aside from numerology, which must be dispensed with in terms of pure design problems, the major stumbling block in the study of mediaeval structures and many of their published plans has been the interference of mathematics and complex geometry superimposed upon perfectly logical and self-contained structures by overspeculative recent viewers.[7] It is true that Boethius provided the general basis of mathematical and geometric speculations until Adelard's translation of Euclid came out in the revised and immensely successful annotated edition of Johannes Campanus de Novara in 1254.[8] But the fact that the theoretical underpinnings for the geometric development of mathematically irrational proportions, including the golden section, can be considered known from that date onward did not prevent the architects from using them earlier. Thus the lodges in charge of Italian "Proto-Renaissance" buildings used a rectangle constructed in the following fashion: A square is halved; and the diagonal of the upper rectangle, used as a radius, is swung outward and brought in line with the side of the square, thus determining the side of a rectangle which will have the proportion of the golden section. This technique was used unsystematically and whenever necessary, indicating that its exalted geometric position was unknown. In this and many other practical cases, a utilitarian approach to design existed without a theoretical geometric basis. The proportions discussed hereafter are therefore not part of a geometric theory but form a body of convenient rules for a pleasant design solution. This is true for the Gothic standard rectangle which was constructed simply by swinging the diagonal of a square until it met one of the sides, thus establishing the long side of the new shape. This standard

6. This translation is from M. H. Morgan, Vitruvius, *The Ten Books on Architecture* (New York, 1960), p. 6.

7. See G. Lesser, *Gothic Cathedrals and Sacred Geometry* (London, 1957), and others.

8. H. R. Patch, *The Tradition of Boethius* (Oxford, 1935), and A. C. Crombie, *Medieval and Early Modern Science* (New York, 1959) I, 44 and II, 6. Adelard of Bath's translation of Euclid from Arabic (ca. 1126) and the *Elements* by Gerard of Cremona and Herman of Carinthia precede Johannes Campanus whose revisions and commentary of Euclid made his edition a standard textbook. See G. Sarton, *Introduction to the History of Science* (Baltimore, 1931), II, 167.

rectangle was used frequently, as in Strasbourg's façade plan B, the nave of Amiens cathedral, and perhaps in sheet A of the Rheims Palimpsest.

These are single units. But Gothic design was usually based on a modular geometric progression which governed the plan and elevations from St. Denis to the sometimes overdesigned fifteenth- and sixteenth-century structures in the German-speaking areas. It is not at all surprising that among the huge material on hand only about a dozen plans contain an actual scale in "schuech," or other units including "roman" feet. Villard de Honnecourt gave measurements only for the construction of a catapult. Numbers are usually reserved for texts where they are frequently used as exempla typifying the construction of medium-sized structures whose wall thickness would vary little.

For this reason Horn's concern about "dimensional inconsistencies" found in this enlightening discussion of the ninth-century plan of St. Gall becomes a minor point compared with his general analysis of an over-all modular grid which governed the layout of the monastery.[9] Looking toward Romanesque concepts one might say that in the plan of St. Gall the basic module could have been determined by the square crossing of the church. The side of that square was easily subdivided into sixteen or thirty-two parts by continuous halving, establishing thus, as Horn states, submodular squares. Within this system the "super module" of sixteen crossing squares—if used at all in practice—would have served as a rough checking device. Minor deviations from the geometric grid during construction were unimportant for the architect who understood the system, and could proceed with the erection of buildings based on any convenient absolute side length of the crossing square, including local units. The actual indication of measurements in feet seems incidental and would have been unnecessary for any architect aware of the modular grid. In most of the later plans containing an indication of actual dimensions, these seem to have been afterthoughts. We know from the impractical scales used in most Gothic over-all plans that the architects, aware of the shrinkage of parchment and the slippage of rulers, would not multiply a distance on the plan by some incongruous factor, but would proceed from one basic repeated distance to which they gave a reasonable number of feet. This module and its major geometric subdivisions were available as a standard on the site or in the lodge (Reissboden). One could then return to the plan whose logical (and thus modular) geometric progression would reveal the procedure by which the size of specific parts of the building could be derived.

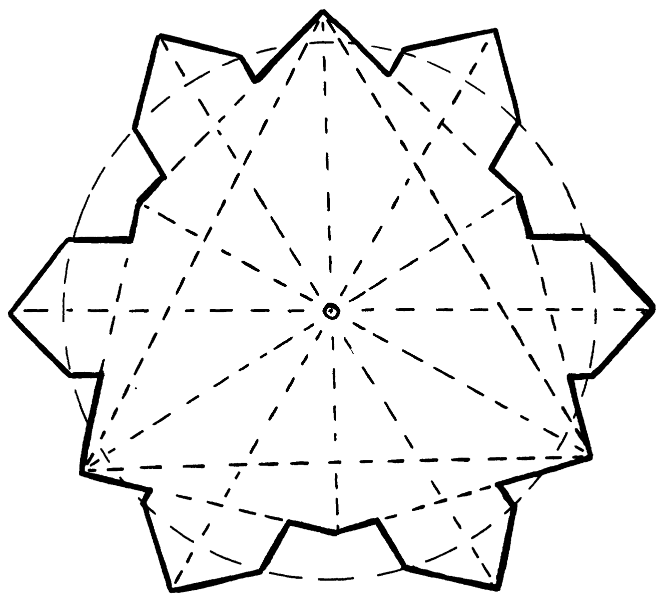

Fig. 1. Ulm Cathedral. Tabernacle pier.

In the plan of St. Gall and in many Romanesque and early Gothic structures this modular progression is simply *additive* and does not therefore usually produce any irrational numbers. Examples of this type are many, among them the Romanesque cathedral of Winchester, plans and elevations of many Cistercian churches or even whole abbeys as Jervaulx (Joraval) in Yorkshire. The more sophisticated use of geometry in Gothic usually includes, on the contrary, irrational mathematical sequences resulting from *dynamic* geometric manipulations whose arithmetic implications were irrelevant. It is of course true that the square in which another square turned at a 45° angle is inscribed etc. is determined by a system of proportions based on $\sqrt{2}$, while the proportion for the "golden rectangle" discussed above includes $\sqrt{5}$. It would imply a misjudgment, however, of the Gothic design process to assume that the theoretical implications of the construction of a finial or baldachin through a series of rotating inscribed polygons or through the repetition of a circle inscribed in a square bothered the architect (Figs. 1, 7, 18). Such theoretical considerations rarely influenced the development of planning, a notable and somewhat comical exception being the Milan controversy concerning the relative virtues of the equilateral triangle and the triangle inscribed in a square.[10]

9. W. Horn, "'Dimensional Inconsistencies' of the Plan of Saint Gall and the Problem of the Scale of the Plan," *Art Bulletin*, XLVIII (1966), 285–308.

10. J. Ackerman, "Gothic Theory of Architecture at the Cathedral of Milan," *Art Bulletin*, XXXI (1949), and W. E. Kleinbauer, "Charlemagne's Palace Chapel at Aachen and its Copies," *Gesta*, IV (1965), 2–11, Figs. 3, 4, 14, for earlier uses of the triangle in the elevation. For a more complex and rather exceptional approach see S. McK. Crosby, "Crypt and Choir Plans at Saint-Denis," *Gesta*, V (1966), 4–8.

A typical example of the complex effects reached through simple geometric steps is to be seen in one of the piers in the outer frame of the 100-foot-high tabernacle in the Minster of Ulm. Designed before 1469, most of its parts cannot be readily understood without recent templates of cross sections (Fig. 1). The piece is based on an equilateral triangle surrounded by a circle. From the three points lines are drawn bisecting the sides. They serve to establish right angles over the corners of the triangle whose extensions intersect the bisecting lines to thus form an unusual hexagon, whose sides are easily subdivided into six equal parts. Two of these units are measured off from the right angle, one from the obtuse angle establishing the width of the projecting elements. Their length is determined by a circle whose radius corresponds to the side length of the hexagon or more directly yet by a regular circumscribed hexagon plus a capping by 90° triangles. The piece could not have been designed in any simpler fashion and it is interesting to note that the blind lines of a template designed in the recent past by the master mason responsible for recutting this piece adheres to this geometry.

We cannot allow ourselves to forget that the architect's primary tools consisted of a straight-edge, a square, a compass, and a divider. Rules including the construction of any inscribed polygons were based on the use of these instruments. Thus we almost always deal with design precepts which had lost any connection with theoretical geometry or mathematics.[11]

There are many indications that these precepts, which had become one of the determinants of a standardized approach to Gothic design by the end of the thirteenth century, were used experimentally and less dogmatically in earlier structures. At first glance the south transept rose window of Lausanne Cathedral (before 1235) seems to have been developed along the simplest geometric progression (Fig. 2). In the most recent publication of the rose window, E. J. Beer compares its construction with Villard de Honnecourt's exempla of the halving of the square.[12] A closer look at this window, as demonstrated in a schematic sketch which was not based on a measured elevation, shows that the progressively inscribed squares define first the outer limits of the frame, but then the inner edge of the central frame as well (Fig. 3). The next two steps lead to the diameter of the innermost circle. E. J. Beer automatically assumed that the four circles attached to the clearly defined

11. The solutions used for theoretically and mathematically "impossible" problems, such as the construction of the heptagon through a complex subdivision of the diameter of a circle in which it was to be inscribed, as well as the frequent use of a rotating polygon especially in Italy, will have to be discussed in a future article.

12. The use of the "rotating" square cannot be discussed here. The technique was used in classical antiquity and in the Romanesque period, including ornamental motives. See F. Bucher, *Notre-Dame de Bonomont and the earliest Cistercian Abbeys of Switzerland* (Bern, 1957), p. 110, Pl. 3. For Lausanne see E. J. Beer, *Die Glasmalereien der Schweiz vom 12. bis zum Beginn des 14. Jahrhunderts* (Basel, 1956), p. 26.

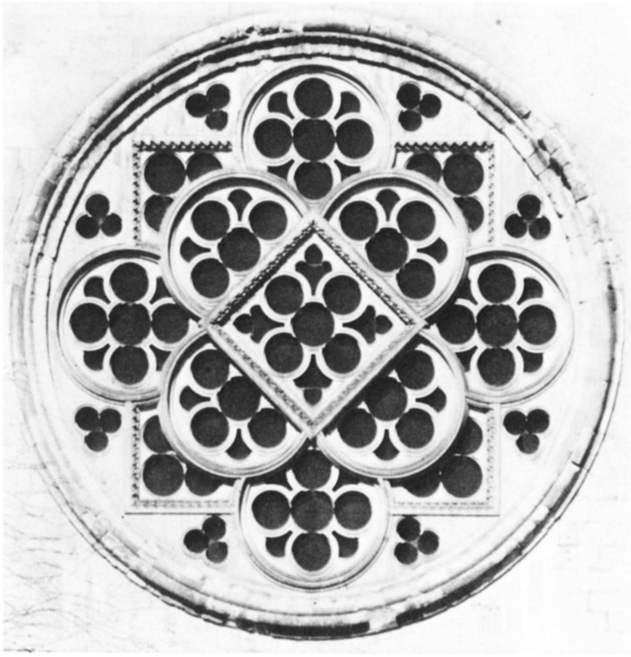

Fig. 2. Lausanne Cathedral. Rose window, South Transept.

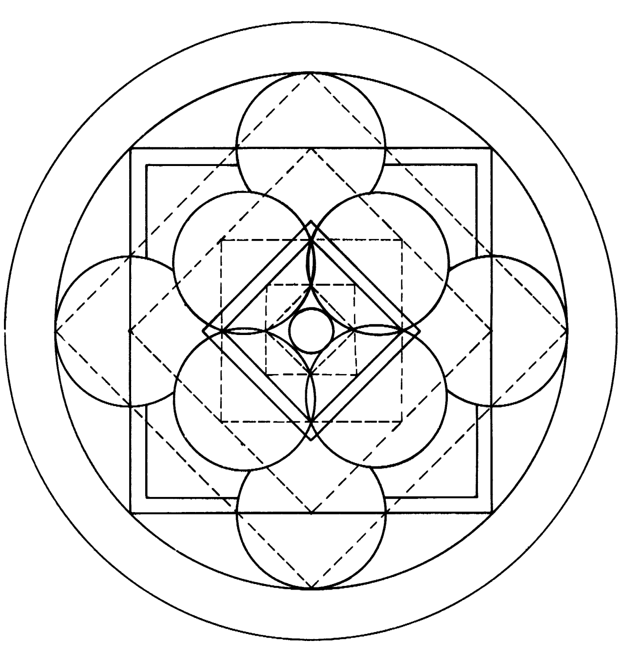

Fig. 3. Lausanne, rose window. Schematic analysis.

inner square could be aligned with the sides of a square equal to and constructed at a 45° angle of the first inscribed square (Fig. 4). This is not so, but I can find no logical reason for the choice of the centers for these four circles beyond a conscious wish to create a breach in the geometric modular inscription and thus save the rose window from a more heavy-handed appearance.

We must conceive of the early thirteenth-century architect as less of an academician than his later counterpart. How little Villard de Honnecourt himself was bound by the rules which he himself helped to establish becomes evident in his own drawing of the Lausanne rose window in which he completely missed the simple geometric development on which the original concept was based, and which he should have remembered even if he drew the rose from memory (Fig. 5). A fifteenth-century architect would have built the same rose in a predictable fashion, thus regularizing it as indicated in the hypothetical sketch in Figure 4, which is far from reality but almost certainly identical to the original lighter and more boring concept for the rose.

Recently, art historians have become wary of the regularization of Gothic plans by incompetent designers. It is ironic that a study of original designs brings some of these nineteenth- and twentieth-century mental constructions closer to the original ideals of the architects than true images of the existing irregular buildings. But we have to realize that the modular discipline of the plans was so rigorous, that it allowed for deviations from the norm during construction. There is reason to believe that these irregularities were consciously condoned by architects who realized the limitations inherent in too rigid a system.

The simplest proportional element in the hands of the Gothic architect was progressive squaring. The simplicity of the design of a compound pier derived from a series of similar plans is astounding (Fig. 6). The defined side A of a square gives the diameter of the circular core of the pier. The first inscribed square with a side measuring an irrelevant $\sqrt{2} \times \frac{A}{2}$ gives the diameter of the shafts facing the nave and the side aisle while the next smaller square $\frac{A}{2}$ determines the diameter of the shafts parallel to the nave.

A didactic drawing in the Akademie der bildenden Künste in Vienna (No. 17090), which may have been an examination sheet, demonstrates the almost mechanical use of progressive squaring for the construction of a pier base, the depth of a mullion in relation to it, and the moldings of the pier which are determined by the short sides of the triangle formed by the intersection of the squares (Fig. 7). The drawing at the right exemplifies the progression through which we arrive at rectangles determined by the addition (or in the second case by the subtraction) of the height of the triangle formed by the 45° revolution of the same basic square. The mathematical implications of these progressions were irrelevant for the architect. As we shall see, the same approach characterizes the construction of almost all parts of a building, down to the last details as found in the window mullions. One of many unpublished exam-

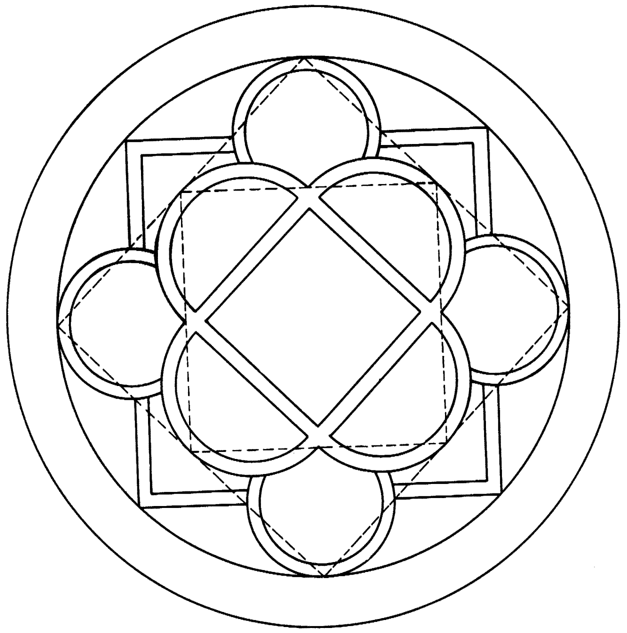

Fig. 4. Lausanne, rose window. Presumed original concept.

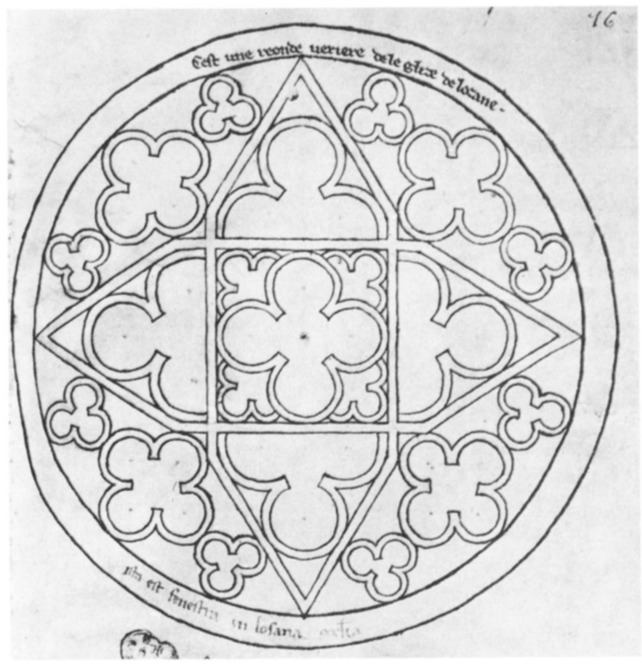

Fig. 5. Villard de Honnecourt. Lausanne rose window.

ples is found on page 28 of the sixteenth-century Frankfurt sketchbook by Master W. G. (Fig. 8).[13] Progressing inward, the diagonal of the fourth square results in the width of the mullion. One quarter of the side length of square three gives the length of the straight parallel faces of the wider inside frame. Fixed in the top corners the compass determines the mullion profile beginning from the outer edge of the inner frame to the intersection with the second square. A connecting horizontal line completes the inside part. This line is projected down, giving the width of the outer edge of the mullion. The same distance seems to determine the anchor point for the compass describing the outer profile, but the compass can also be shifted to meet both the widest point of the mullion and the outer edge. The two unpredictable procedures concern the width of the frame to which the window was to be attached, and the size of the hole into which the bronze dowel could be placed and fastened with hot lead.

It would be interesting to discuss the survival of Gothic geometric systems in the designs of later craftsmen. The square and the standard rectangle were used into the seventeenth and eighteenth centuries in the construction of barns.[14] A design for the restoration of gable tracery over the external lower windows of the west façade of Cologne cathedral shows the process used by Willy Weyres to reconstruct the seemingly complex motive (Fig. 9).[15] In the terms of Jean Mignot, as expressed in 1400, the drawing at the right represents *scientia*. The masons used it in conjunction with the drawing at the left which deals with *ars* since it stresses the single measured pieces of carving. Except for the absolute measurements the very same approach appears in many lodge-books as, for instance, on pages 12, 25, 27 of the unpublished lodge-book of Wolfgang Rixner in Vienna.[16] The reader can rediscover for himself this simple

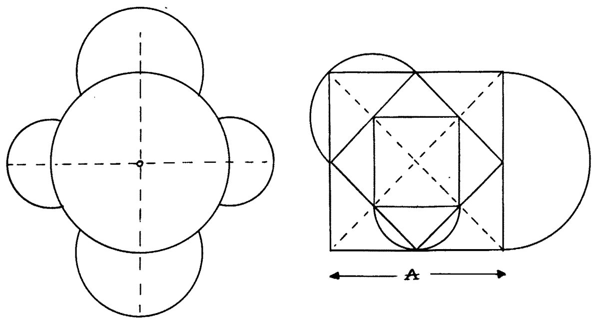

Fig. 6. Geometric construction of a nave pier.

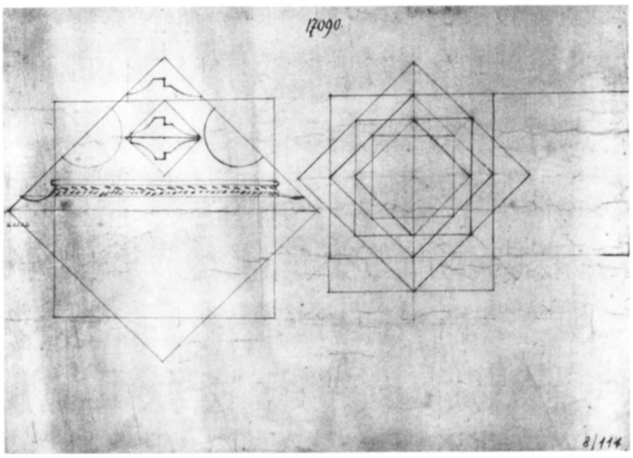

Fig. 7. Geometric construction of a base and a mullion (Vienna Akademie).

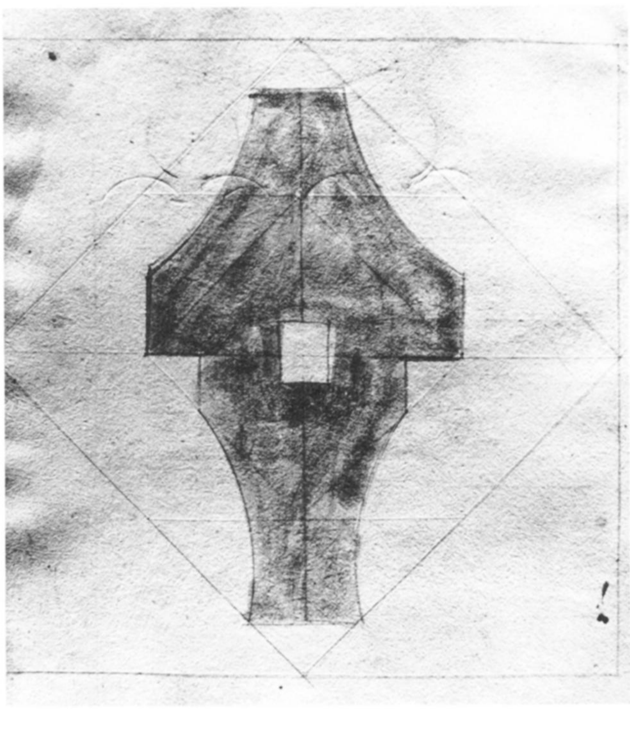

Fig. 8. Construction of a window mullion (Frankfurt, Städel).

13. The sketchbook is in the Städelsches Kunstinstitut in Frankfurt. I hope to publish this document in the near future.

14. K. Baumgarten, *Zimmermannswerk in Mecklenburg, die Scheune* (Berlin, 1961). See especially the Zehntenscheune Retelsdorf bei Schönberg, Fig. 40 and Schönberg, Fig. 120. The wooden roof structure in the tower of Oron near Romont was based on the halving of the square and will be published by the author.

15. The construction used by Dr. Weyres echoes similar designs in mediaeval sketchbooks, some of which were unknown to him. Many of the traditions still adhered to in the present-day lodges are so strongly reminiscent of Gothic design theory, but not based on a direct knowledge of Roritzer and others, that one has to assume an unbroken design tradition, or otherwise simply a sensible re-creation of Gothic design procedures by the masons. The uncanny ability of good masons to deal with geometric proportions may reflect the easy familiarity with geometry which characterized all the mediaeval plans.

16. See K. Rathe, "Ein Architektur-Musterbuch der Spätgotik mit graphischen Einklebungen," *Festschrift der Nationalbibliothek in Wien* (Vienna, 1926), pp. 667–692; P. Frankl, *The Gothic* (Princeton,

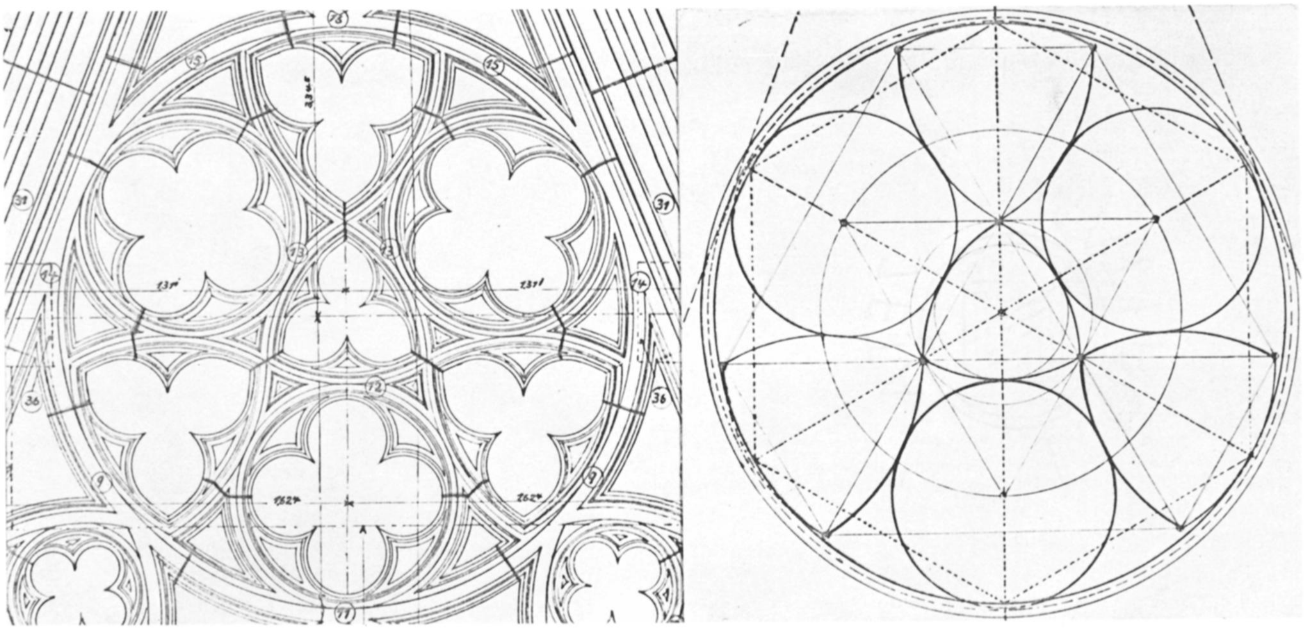

Fig. 9. Cologne. Reconstruction of tracery by W. Weyres.

construction with the help of the tools used for thousands of similar drawings: the compass and the square.

THE PLANS

The bulk of the plans and lodge-books on which this essay is based range in date from 1350 to 1572 and geographically from Paris over Strasbourg to Prague and back again to Austria and South Germany. The material falls into the following categories, each of which would deserve a lengthy separate discussion.

I *Theoretical Designs*
- (1) Demonstrations of geometric progressions (Figs. 7, 13, 14),
- (2) Exempla of "good" solutions,
- (3) Exempla of projections, cross sections, and elevations (Figs. 6 and 8),
- (4) Design tricks such as reduction of enlargement, the construction of "spirals," "ellipses," etc.

II *Educational Plans*
- (1) Exempla of basic geometry (Fig. 14),
- (2) Examination drawings (Fig. 13),
- (3) Geometric solutions for the definition of sizes of most details in a building (Fig. 14),
- (4) Lettering samples (ABK 16.839).

III *Working Plans*
- (1) Original sketch plans (Figs. 9, 26),
- (2) General preliminary plans and elevations (Figs. 15, 16),
- (3) Show plans for the building committee (Figs. 23, 25),
- (4) Intermediate working plans dealing with segments of the structure or specific problems,
- (5) Detail plans of ribs, profiles, etc. (Figs. 17, 28),
- (6) Simplified line drawings for the study of proportions and location of keypoints for measurement,
- (7) Full size preparatory drawings for the cutting of templates,
- (8) Staircase plans (Figs. 21, 23),
- (9) Placement or positioning charts (Fig. 20),
- (10) Contractors' samples of vaults and other details, a number of which are cutouts (Fig. 30),
- (11) Designs for church furniture as tabernacles, pulpits, baldachins, screens, monstrances, etc. (Figs. 26–29).

IV *Special Plans*
- (1) Freehand sketches of existing structures (Figs. 32, 33),
- (2) Lodge copies made for the use at another site (Fig. 15),
- (3) Memorial views retained as family keepsakes or destined for publication (Figs. 32, 33),
- (4) Master drawings displaying conscious virtuosity,
- (5) Architectural fantasies (Fig. 31).

1960), pp. 145–146. Frankl's date has to be corrected, since the sketchbook originated ca. 1470–1490 and was still being added to in 1486. See also P. Booz, *Der Baumeister der Gotik* (Munich, 1956), pp. 30, 41, 43–44, 47, 85. Dr. J. Weitzmann-Fiedler and I are preparing a (complete) edition of the Vienna sketchbook. For a general discussion of pattern books see R. W. Scheller, *A Survey of Medieval Model Books* (Haarlem, 1963).

V *Sketch and Lodge-books.* These books were used by the architects and masons, and by the lodge. They fall into the following categories:
(1) Personal note- and sketch-books ranging over large areas of Gothic architecture including the lay-out of buildings, triangulation, bisection of angles, etc. (Fig. 8),
(2) Pattern of model-books destined largely for the inspiration of the patrons (Fig. 30),
(3) Technical works on construction and machinery,
(4) Leafcutters' books,
(5) Theoretical treatises usually on one aspect of the construction. These were mostly destined for teaching or even, as in Roritzer's or Lacher's cases, for publication,
(6) Diaries on the progress of construction,
(7) Shop-manuals bound or unbound,
(8) Accounts.
Omitting the last three items there are roughly fifteen of these books preserved, most of them unpublished.

VI *Elements involved in Planning.* We cannot here deal with the elements forming part of the design process and which were stored in the lodges. These were:
(1) Templates,
(2) The "Reissboden" or 1:1 modular basis available in the lodge or on the site on parchment or incised in stone,
(3) Stone samples,
(4) Instruments such as the usual one-foot compass, and dividers of very much larger size as well as iron or bronze pens.

VII *Architectural Models.* An echo of the mediaeval lodge is still preserved in San Petronio in Bologna and in the Fabbrica del Duomo in Milan which contains plans, details and complete models, samples of work in wood and stone, etc.

THE SKETCH PLAN

One of the most significant Vienna sketches shows a quick first concept for a highly dynamic vault. After the delineation of the square it was dashed off entirely with a compass and it is easy to reconstruct the whole process, which may have been partially determined by the size of the sheet (Fig. 10).[17] The quick, almost sloppy design, which was of course followed by intermediate and detailed sketches, and possibly a show plan, betrays the eye of a master, in this case presumably that of Benedikt Ried or Rejt. That a sketch so

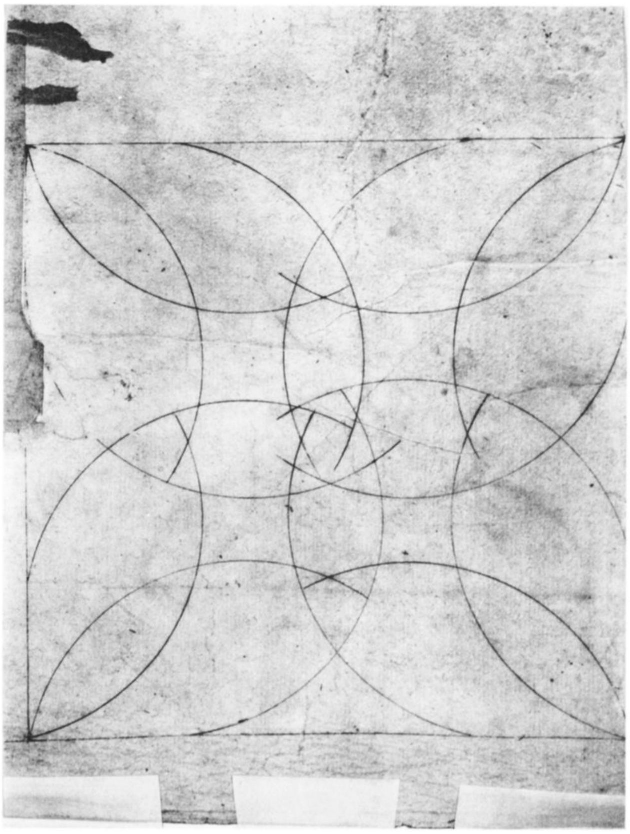

Fig. 10. Sketch for the Rider Stair, Hradčany, Prague (Vienna Akademie).

simple could have been enough to convince him that this type of vault would fit the complex sloping roof on the Rider's Stair in the Old Hradčany Palace in Prague where he erected the vault a few years after 1500, speaks for an amazing versatility in stereotomic conception (Figs. 11, 12). There were earlier, similar designs which Ried was able to remember, as for instance one of the vaults over the south gallery in the Salvator Church in Passau begun in 1479. But he was also completely conversant with the Parler workshop tradition not only through his presence in Prague but also through his plans for the completion of St. Barbara (or the "Miners' Church") in Kuttenberg between 1512 and 1548. Its choir had been begun by Peter Parler in 1388. Interestingly enough the council of Kuttenberg, noting his failing health, asked Ried to deliver his plans to the town against payment in 1529 (Akademie der bildenden Künste, No. 16841). He used his exceptional skills over a decade in major works in the Old Palace including the fortification of the Hradčany, and the Vladislav Hall (1493–1504) from which the Rider's staircase originates. G. Fehr, who does not mention the sketch, was impressed by the irrational elimination of the keystone, compares it with

17. Vienna, Akademie der bildenden Künste, No. 17065.

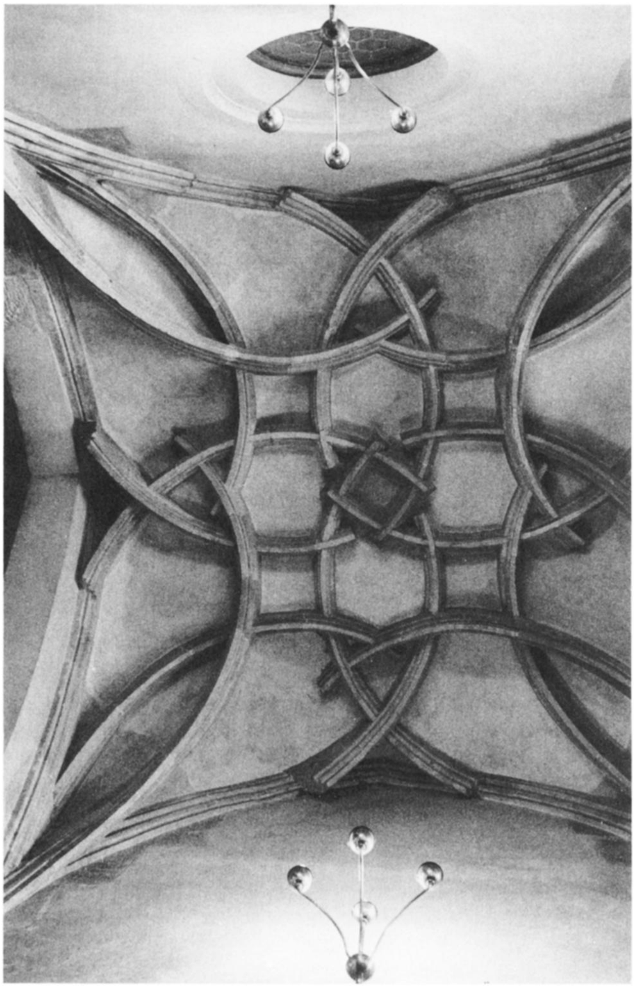

Fig. 11. Rider Stair, Old Palace, Hradčany, Prague ca. 1503–1505.

Fig. 12. Rider Stair, Hradčany, Prague. View from below.

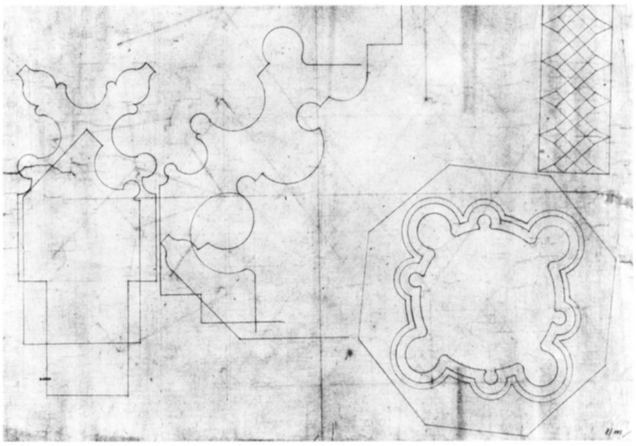

Fig. 13. Examination sheet (Vienna Akademie).

fireworks, and feels that it gives the "impression of becoming."[18] That the immediacy of an unconventional sketch could be transposed into reality, speaks for a remarkable consonance between architectural concepts, detail work, and workshop execution reached in the late Gothic period. In addition, the sketch stands for a complete grasp of the possible. As a quick vision it already carries within itself the finished work.

18. In a recent discussion, Prof. Koepf disagreed with my identification of the sketch, and I am anxious to see his interpretation in his forthcoming book on the Vienna Plans, at which point my attribution might have to be reconsidered. For a discussion of the Rider-Stair see G. Fehr, *Benedikt Ried, Ein deutscher Baumeister zwischen Gotik und Renaissance in Böhmen* (Munich, 1961), p. 31, Pl. 25, and Václav Formánek, *The Prague Castle* (Prague, 1965), p. 58. Ried died 30 September 1534, by which time he had been experimenting with the new Renaissance forms. Fehr analyzes his influence and that of his school on some of the most sophisticated late Gothic churches (e.g. St. Anna in Annaberg [completed 1522], the town church of Brüx [1517–1532]) and also on fortress architecture in Bohemia.

EXAMINATION DRAWINGS

The complete assurance with which even minor Gothic architects designed their plans clearly indicates a thorough educational process. By extraordinary luck three sheets dealing with six identical design problems are preserved in the Vienna Academy (Fig. 13). The only difference between them is the arrangement of the drawings, and the quality of the line. Since they deal with simple theoretical problems it is difficult to assume that they were repetitions of figures rearranged for aesthetic reasons. Hans Koepf suggested that these drawings are examination sheets, and there is no doubt in my mind that this is a correct interpretation. The problems posed included four cross sections through a cornice to be inserted into a wall buttress, a rib, an arch profile, and a gable profile. The two remaining questions concerned the design for a vault, presumably based on a modular approach determined by half the length of the smaller side and a division of the 2×5 unit rectangle into three equal long strips. The last and most interesting design is a solution offered for an asymmetrical ambulatory pier. I will discuss the optical questions responsible for the shift of the small shafts on another occasion.

THE KEY-PLAN

Before late Gothic construction began, the parts of the building were carefully correlated. The procedure was based on the standard practice of a derivation from each other of lengths, shapes of profiles, mullions, etc. in a logical sequence. About fifty preserved drawings explain this process, which was highly complex and is not yet clear in spite of the fundamental work by Paul Booz.[19] Sequences of parts based on a master square from which every structural and decorative member was derived were a part of every late Gothic sketch book, and were also kept in lodges for educational purposes. One of these sheets is in Vienna (Akademie der bildenden Künste, N. 16992 R) and contains cross sections of a window mullion, window embrasures, a door jamb, a cornice, and a free-standing mullion (Fig. 14). It is difficult to establish a consistent sequential order of steps which must have been customary in devising the size of each detail. We must not however forget that these key plans, which were enlarged to the actual size of the projected pieces on a platform located within or as closely as possible to the building site, were already the result of a series of preliminary drawings of parts of the structure. All late Gothic architects were familiar with the design techniques used—for instance—for the construction of a mullion discussed above (Fig. 8). Similar procedures were used to determine not only the height of the blocks used for a buttressing tower, but also to define the width of the cornices and of the major decoration of pinnacles long before Roritzer's *puechlein* of 1486.[20]

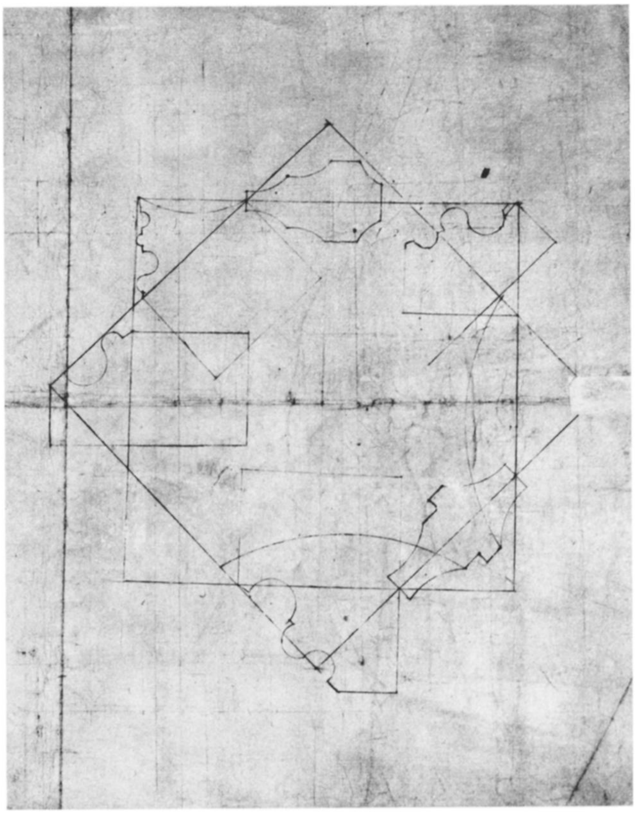

Fig. 14. Key Plan (Vienna Akademie).

Details of large structures required a careful design procedure all by themselves, which eventually was integrated into over-all plans (Fig. 17).

THE GENERAL PLAN

Plans of complete buildings or elevations have continued to capture the attention of scholars partially because of their early dates, or the importance of the structures which they originated. The Rheims Palimpsests A and B, the Strasbourg Façade Plans A and B and the first tower elevation of Freiburg im Breisgau are thirteenth century while the magnificent plans for Cologne cathedral and St. Stephen in Vienna reach into the fourteenth century and beyond. To these I should like to add the plans on sheet 21 in the Oeuvre Notre Dame, Strasbourg, which have received little attention. On one side we find a highly accurate layout of the somewhat heavy-handed choir of St. Croix in Orleans (Fig. 15). Sheet 21 verso shows the chevet of Notre Dame in Paris.[21] These plans seem to be fourteenth-century copies of

19. P. Booz, *Der Baumeister der Gotik*. The clearest analysis of the sequential process involved in the determination of sizes of architectural members is found in Lorenz Lacher's *Unterweisung* of 1516. Booz uses Lacher (Figs. 12, 13, 17) and the Vienna sketchbook (Fig. 19, pp. 41–42) to explain the geometric and measuring techniques used to determine shapes and then to reuse the same profile for smaller pieces. This is a practice still applied in present-day lodges. For a "master-plan" destined to be transferred to the "Reissboden" see Booz, Fig. 18.

20. A sheet in Vienna, Akademie der bildenden Künste (16868 R) shows the base of a pinnacle, which is presumably composed of three large blocks, in the form of a square which is superimposed upon the uppermost part of the pinnacle. The next inscribed square determines the size of the cornice at the bottom of the top part of the finial, the third square establishes the width of the base of the piece, and the fourth square the size of the abstract floral ornament at the top. Other sketches preserved in several lodges indicate the procedure used to determine the height of each block used to build up a pinnacle.

21. P. Booz, *Baumeister*, p. 74, states that the scale of the Orleans plan is 1:105 and that of the Paris Notre-Dame plan is 1:108. See also O. Kletzl, "Planfragmente," p. 10. O. Kletzl's "Ein unbekannter Pergamentplan der Münsterbauhütte Strassburg," *Forschung und Fortschritt*, XIV (1938), 249, and "Ein Werkriss des Frauenhauses von Strassburg," *Marburger Jahrbuch für Kunstwissenschaft*, XI (1939), were not available to me.

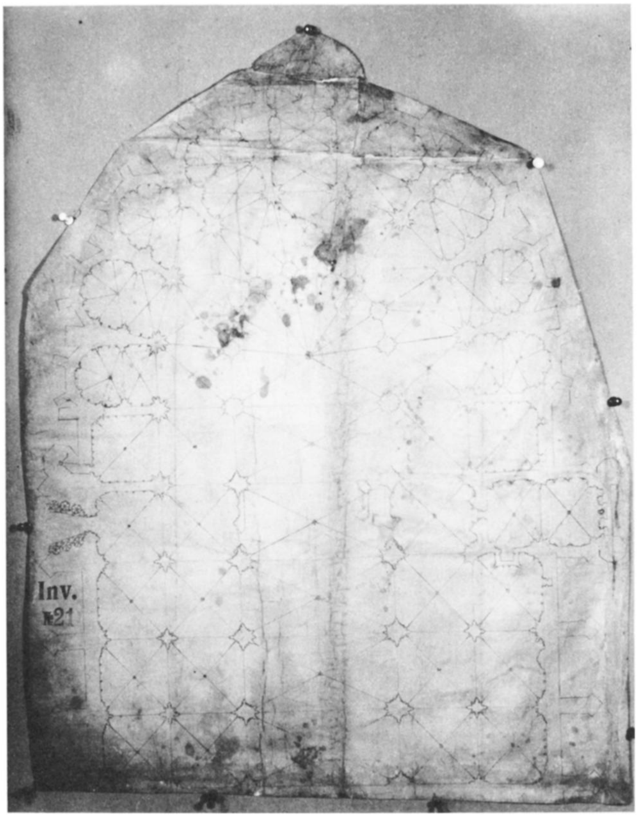

Fig. 15. Orleans, St. Croix, chevet (Oeuvre N. D. Strasbourg).

the original plans for the choir of St. Croix which was begun in 1287, and for the transformation of the ambulatory in Paris made specifically for the use of the Strasbourg lodge.

The simplicity of the layout in both plans is astounding. The plan of St. Croix is especially interesting since it is not only the last royal cathedral of the Ile de France, but also contains dying echos of the plan of St. Denis. Branner characterized the existing structure as "ponderous" and representative of the "academic thinking of the time . . . ."[22] Compared with the eccentricity of the original prototype, this plan, with its nine chapels, is indeed heavy and strangely archaic; but the emphasis on new inventions and on refinement was shifting to the German-speaking areas and to England and was made possible by an increased emphasis on design.

The linear precision of the over-all plans continues to be one of the hallmarks of the late chevet designs. The mid-fifteenth-century intermediate plan for the choir of the town church of Steyr in upper Austria by Hanns Puchspaum was drawn on a sheet of paper measuring 74.5 × 54.6 cm. and is based on his first parchment plan. The module of standard rectangles and squares ignores the wall thickness as in the plans of Paris and Orleans which were based on triangulation and addition of squares. Absolute clarity and simplification of details characterize a plan from the Parler lodge now in Stuttgart and the unpublished plans of the chevets of the cathedral of Zagreb in which the ribs are indicated by three parallel lines. The same is true for the experimental phases of planning for the cathedral of Augsburg and St. Barbara in Kuttenberg.[23]

Excluding elevations, the plan for the North tower of St. Stephen in Vienna is perhaps the most sophisticated architectural design of the Gothic age (Fig. 16).[24] Drawn on a sheet of parchment measuring 83.5 × 82 cm., it was almost certainly conceived by Hanns Puchspaum shortly before 1450. In a number of Gothic plans several stories, if not the total vertical development, is given on one sheet showing superimposed cross sections (see also Figs. 17, 26–29). This technique had the advantage of providing a key for all horizontal measurements on one single sheet. In plans of complex structures the reading is made difficult due to cantilevered parts, and one has to refer back to the elevation

22. R. Branner, *St. Louis and the Court Style in Gothic Architecture* (London, 1965), pp. 110–111. G. Chenesseau, *Sainte-Croix d'Orléans* (Paris, 1921). Neither author discusses the plan.

23. For the plan of Steyr (Austria) see B. Grimschitz, *Puchspaum*, pp. 23, 48 and Fig. 42. Fig. 46 shows the existing church. The plan for the vault of the nave was realized, the patterns for the side aisles were made more elaborate. The plan is in the Vienna Akademie (17052) and is a copy of a parchment plan also in the Akademie (16980). A third plan (17029) was used at the site. There are additional detail plans. For the plans of Zagreb (Akademie 16926), possibly Augsburg (Akademie 16846) and Kuttenberg or Kutna'Hora (Akademie 16841), as well as a plan fragment now in Stuttgart, see O. Kletzl, "Planfragmente," p. 2, Figs. 9, 11, 12. Kuttenberg was probably begun by Johann Parler, in 1388, and finished in 1499 by Matthias Rajsek. See also G. Fehr, *Benedikt Ried*, pp. 36ff., Figs. 37–47. The Vienna Plan deals only with the spacing of the piers and the buttressing of the ambulatory and side aisles whose rib patterns are indicated.

24. Vienna (Akademie 16827) 33″ × 32½″. See Grimschitz, *Puchspaum*, with Figs. 22–38 including other tower plans for St. Stephen. A drawing of the complete plan is given on p. 11, etc. The blind lines are of little importance for the understanding of the plan. The square was subdivided into four squares; twelve lines repeating the same degree progression originate from the center. Additional finials are defined by blind lines only. The plan is supposed to represent the north tower, but I believe that it is a plan of the south tower. The problem cannot be resolved until the dissertation of M. Magdalena Zykan: *Der Hochturm von St. Stephan in Wien* (Vienna University, 1967) is published. Miss Zykan graciously offered to let me read her highly competent account, but I was unfortunately unable to take advantage of her kindness. According to Grimschitz "Hanns Buxböm" is mentioned in Ulm 1417–1421, and became mason-in-chief in Vienna ca. 1430. On 21 September 1446 he seems to have become master of St. Stephen's lodge and was asked at that time to make plans. Puchspaum redrew the same plan which was later wrongly attributed to Gregor Hauser. It is now in the Archives of the City of Vienna, 146e–239e.

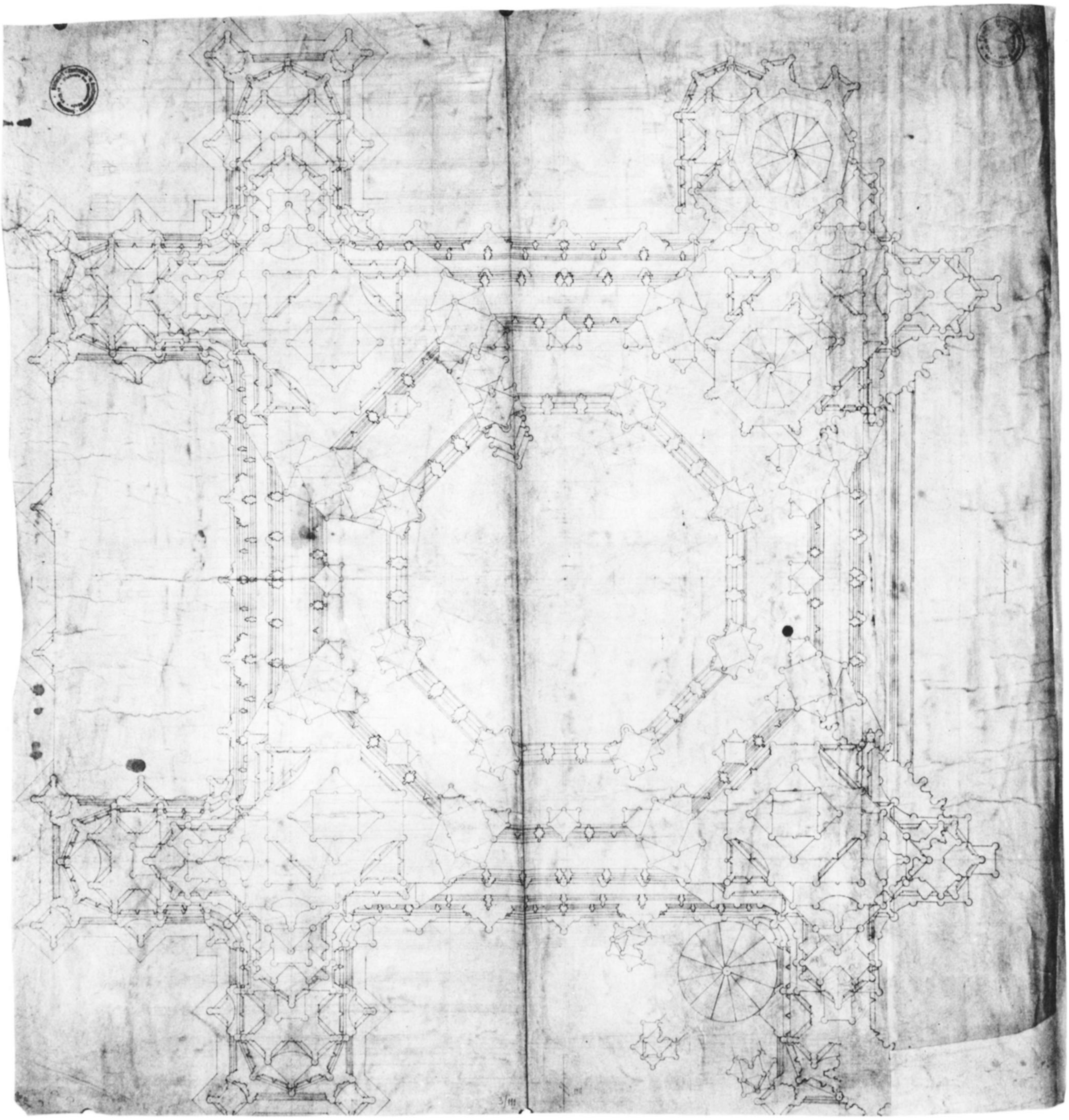

Fig. 16. Vienna, St. Stephen, North tower (Vienna Akademie).

which frequently accompanied the plan either on the same sheet or drawn at the same scale on an accompanying leaf.

Not too many difficulties are connected with Puchspaum's plan, which deals with a regularly receding immense stone cage. The plan includes every important step of the elevation from the socle and the entrance porch (whose vault was designed on a separate sheet) to the giant finials over the corners and ends with the second stone ring of the octagonal spire. Depending on a definition of major breaks in the elevation we can count at least sixteen steps up to and including the corner finials, and an additional seven steps from the upper terrace to the second octagon ring. With the additional three rows of pinnacles above the ring, but excluding the giant finials as separate entities, we therefore arrive at a clear definition of at least twenty-six major construction steps adding up to twenty-two stories. The sophistication required by the designer of such a plan, and by the members of the lodge responsible for its reading and realization is obvious; but a master mason would immediately perceive the simple modular progression from story to story and from finial to finial.

The main module was, as it should be, a square defining the solid core of the tower. Its sides run through the centers of the buttresses and the blind lines can still be seen on the half that does not contain helical stairs. Squares inscribed in this master module give the size of the sub-buttresses down to those jutting from the large buttress at the left. This sequence involves nine design steps excluding the master square. The module for the two interrelated octagons are two radii which correspond to half of the side lengths of the master square and the first inscribed square. The finials and decorative elements of the octagon were derived from another square which was progressively reduced by the usual method, as can be seen in the series of cross sections connecting both stone rings. These general plans were immediately followed by detail studies.

DETAIL PLANS

How careful the planning procedure for details of large structures was is demonstrated by the half plan for a "giant" or perhaps as Koepf thinks, for one of the large baldachins in St. Stephen (Fig. 17).[25] Grimschitz assumed that the plan was intended for a free-standing monument comparable to the Spinnerin am Kreuz; but whatever its eventual purpose, the complexity of the design in terms of irrational distances is such that its concept would have been difficult to explain without the blind lines which are partially visible on the illustration. The geometric technique

25. Vienna (Akademie 16905). See Grimschitz, *Puchspaum*, p. 50, for a mention of this plan. It can be compared to Akademie 16848. The radius of the largest circle is 226 mm. Grimschitz discusses free-standing centrally planned structures, such as the Spinnerin am Kreuz, which were based on similar plans. Another possibility might be a turret as that over the chapel of St. Margaret near the town church of Steyr (Grimschitz, *Puchspaum*, Fig. 50). But similar plans in Italy, which are definitely for large finials, would indicate that we deal here with a "giant"—perhaps for St. Stephen.

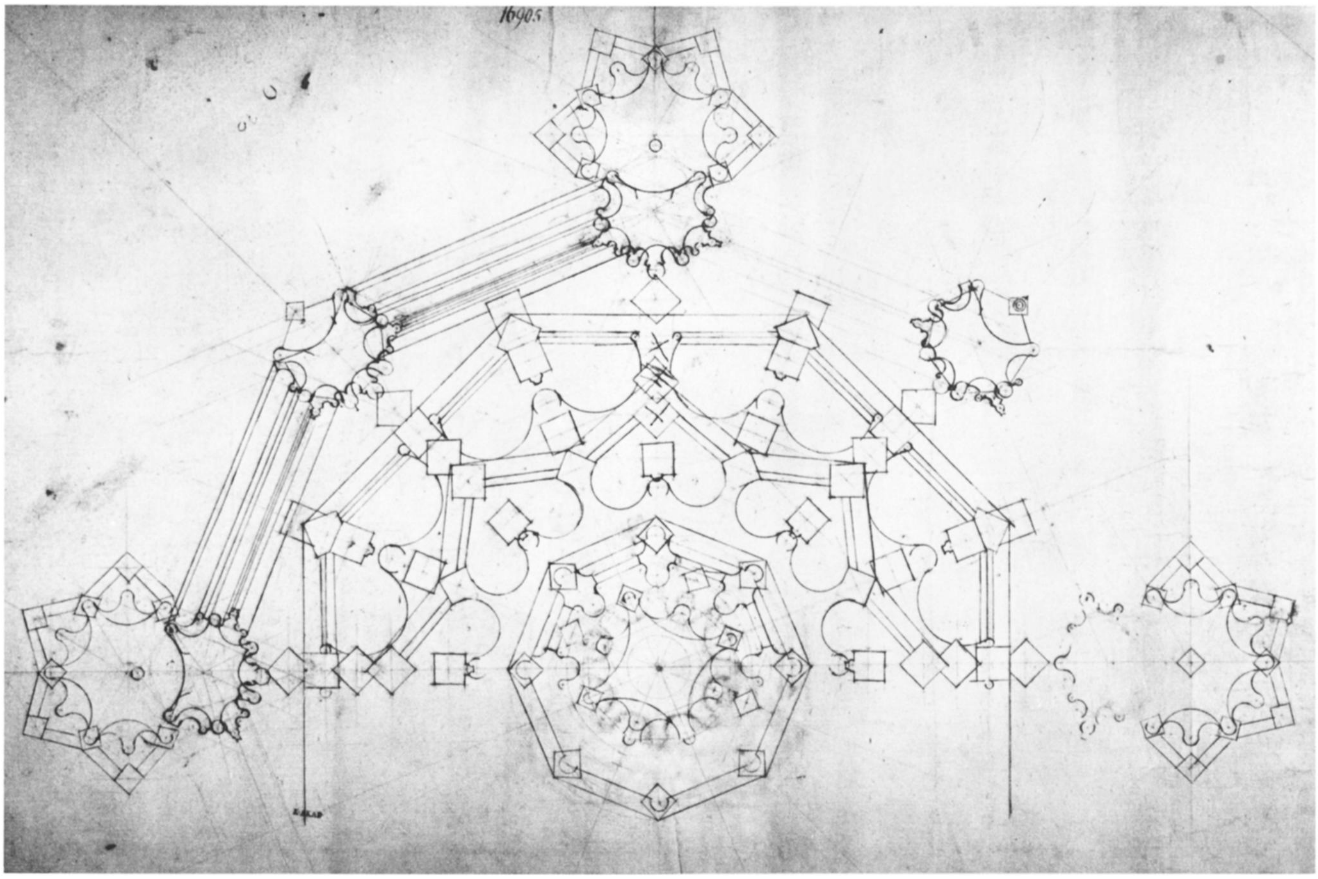

Fig. 17. Half plan for a baldachin or a finial (Vienna Akademie).

which can be found in Italian plans of the fourteenth century consists in circles, each of which is circumscribed by a square which determines the radius of the next circle (Fig. 19). It is useless to speculate on the concern of Gothic architects regarding this complex mathematical progression which was attained by such simple means and produced highly sophisticated and elegant results. Even today the human response to these logical but complex geometric progressions, which have been used by the foremost architects of all ages, is not fully unerdstood. It is clearly evident from mediaeval text precepts that their careful and knowledgeable handling made the difference between a good and mediocre building as far as Gothic criticism was concerned.

PLACEMENT PLANS

The placement or positioning plan was one of the backbones of Gothic construction. It usually consisted in a simple linear copy of an existing working design. For instance, a paper sheet in the Akademie der bildenden Künste in Vienna (No. 17050) shows a double aisled hall with a relatively standard net-vault of the fifteenth century. But it was to contain at least thirty-two ornamental keystones which were carved in the lodge, provided with a mark indicated on the plan, and eventually positioned to match the location indicated in the placement plan (which was consulted each time a keystone was hoisted up).

A more sophisticated plan of the same type, which must be dated before 1547, comes from the workshop of Bernhard Nonnenmacher (Fig. 18). It refers to the sequence of complex doubly curved ribs in the vault of St. Catherine's chapel attached to the south aisle of Strasbourg cathedral.[26] Nonnenmacher's main difficulty in planning the vault was the intrusion of a buttress which could either be ignored through the introduction of a continuous vault pattern or acknowledged by an interruption of the circular module (Fig. 20). The second possibility presented more of a challenge, and the disciplined pattern of four circles and segments of circles based on the same radius allowed for willful inconsistencies achieved through the noncompletion of circles and the trailing ends of "broken" ribs. The double curvature of almost all the elements required a careful search for identical pieces which would effect the greatest efficiency and economy in stone cutting. Thus pieces of the same length and curvature were provided with the same

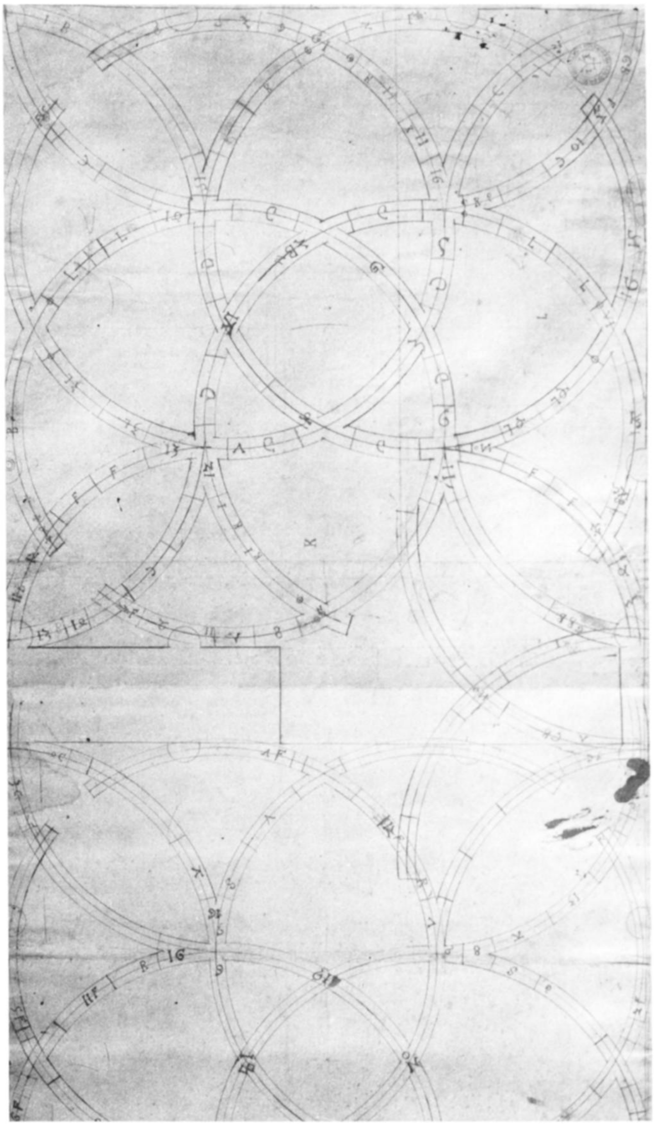

Fig. 18. Strasbourg cathedral. St. Catherine's chapel. Placement plan (Oeuvre N.D.).

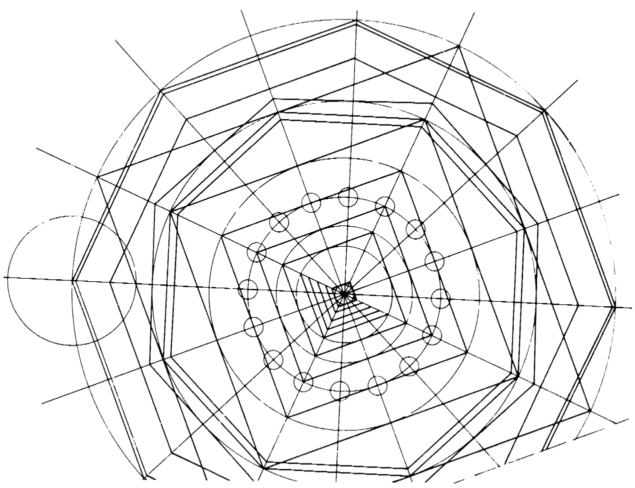

Fig. 19. Schematic analysis of Figure 17.

26. The plan is in the Oeuvre Notre-Dame in Strasbourg. For a brief discussion and partial publication see G. Fehr, *Benedikt Ried*, pp. 108–109 and Figs. 111–112.

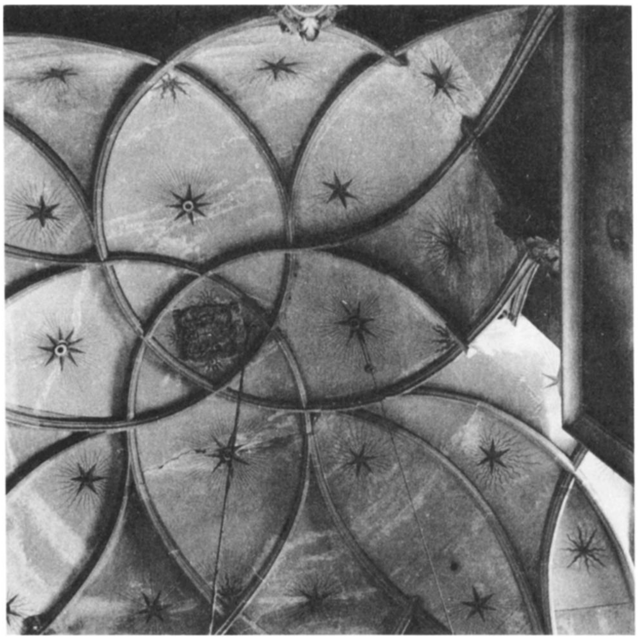

Fig. 20. Strasbourg cathedral. St. Catherine's chapel. East bay.

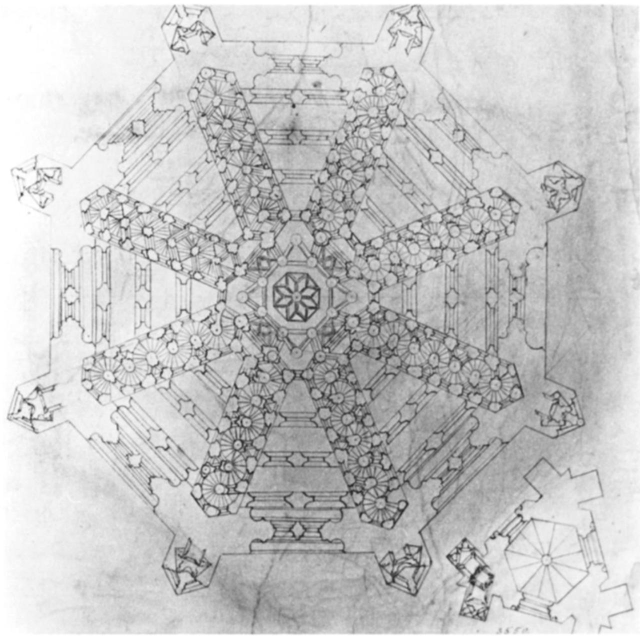

Fig. 21. Strasbourg cathedral, spire (London, Victoria & Albert Museum).

letter. Piece "C," for instance, is always the same length and could thus be interchangeably used in different locations. Other steeply ascending ribs as 13, 14, 4c, 3c, etc. were unique in the vault due to the interference of the earlier construction. The realization of the project shows further changes which may have been decided upon during construction, since they diminish the visual impact of the vault considerably.

STAIRCASES

About 10% or about 250 of the plans which I recently studied deal with the plan, height of tread, or construction of helical staircases. This may seem surprising to anyone who has not seen the pride with which the foremost contemporary master masons will show their reconstructions of Gothic stairs built around straight or swinging spindles in often complex casings. The stereotomic problems connected with helical stairs are indeed so difficult that stairs formed a separate construction category in which the Gothic architect was able to display his design skill and technical mastery.

Among the many designs for stairs, two emphasize this point most clearly. Figure 21, which could be called an orgy of helical stairs, shows in fact an intermediate to late stage of the design for the octagon of Strasbourg cathedral. It is probably a contemporary lodge copy of the original design made after 1419 by Johannes Hültz. The hexagonal staircase turret is derived from the magnificent master drawing attributable to Ensinger now in Vienna (ABK 16832). But this more recent version shows an adaptation to more traditional and regularized standards of taste.[27] The badly drawn staircases in two of the rising arms of the octagon are a typical sign pointing to a lodge copy. A similar simplification is also seen in the plan for the giant south staircase of St. Vitus in Prague which was based on a Parler design.[28] It is interesting that the architect was intent in giving the visual impression of an uninterrupted diagonal movement toward the top which was of course not intended in the monument.

In spite of the fact that the "Schnegg" (snail) built 1438–1440 in the north transept of the Minster in Constance was never considered the eighth wonder of the world, as was the spire in Strasbourg, it nevertheless is one of the most moving monuments to the art of masonry (Fig. 22). The purpose of the structure was to provide a balcony from which the relics of the minster could be displayed. But after an unfortunate reorientation discussed below, the somewhat uncomfortable stair now also leads to the upper quarters of the canons. In view of the obsession of mediaeval architects with helical stairs, this independent structure,

27. The plan is in the Victoria and Albert Museum, London. The drawing in the Vienna Akademie (16832) is illustrated in Freiberg and Hainisch, *Gotische Baurisse*, Fig. 1. It represents a double helical staircase inscribed in an irregular hexagon based on an equilateral triangle. It is the same shape as that used later in the cross section of the Ulm pier (Fig. 1 in this essay).

28. For the Prague staircase see O. Kletzl, "Planfragmente," Fig. 13. The plan is in Ulm and shows no clear distinction between the three receding parts of the stair as it was built.

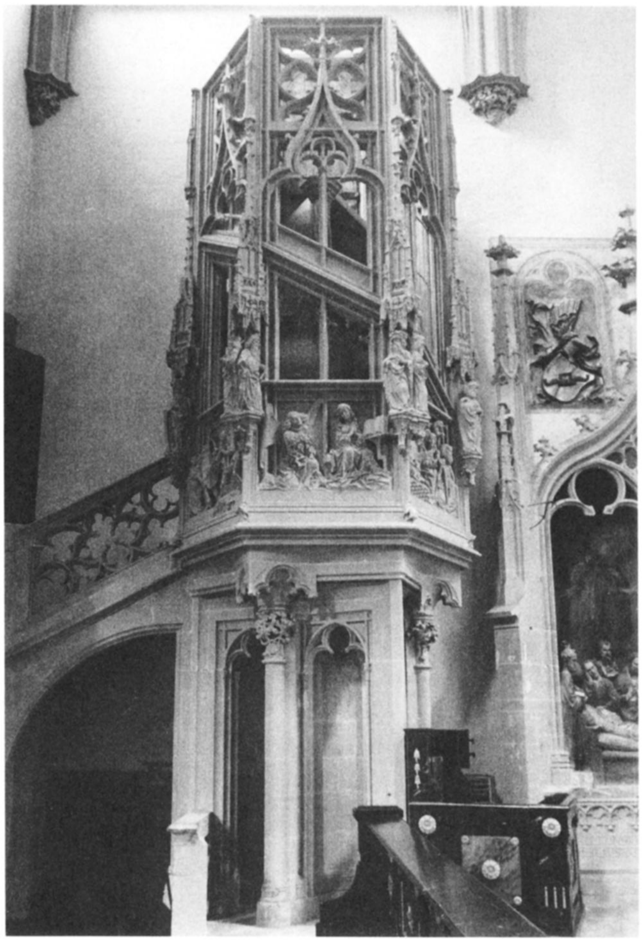

Fig. 22. Constance Minster. "Schnegg," 1438–1440.

whose beautiful design overshadows any intended practical function, seems more like a memorial to the staircase. The show plan, which is now divided into two sheets, proves that the basic proportions which are easily established from two cross sections and from the elevation of the frontal panel were implemented (Fig. 23).[29] But there are important changes in details. The heavy outer frame following the steps, the slightly oversized reliefs, the raising of the horizontal which was to serve as a basis for the top arches and now cuts through them, the introduction of tracery for the banister around the platform, all now interfere with the exquisite lightness of the original design.

The attempt to catch the flavor of three dimensionality through a halving of the sides which run at an angle from the observer still follows some of the techniques already used by Villard de Honnecourt which have been discussed by Hahnloser. The quarter arch at the right indicates the height and width of the profiled arch defining the masonry

29. The plan is mentioned by Freiberg and Hainisch, *Gotische Baurisse*, Nos. 18, 19. The two parts are in the Vienna Akademie (17055, 20.7 × 30 cm. and 17028, 77.3 × 24.6 cm.).

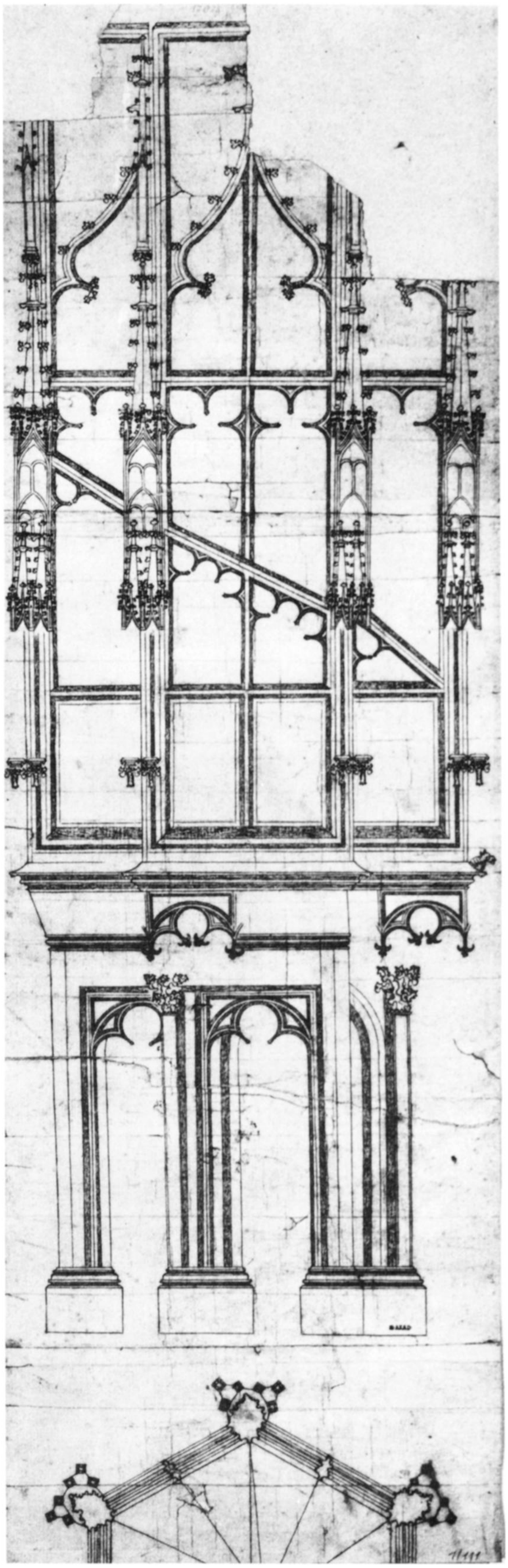

Fig. 23. Plan for the Constance "Schnegg" (Vienna Akademie).

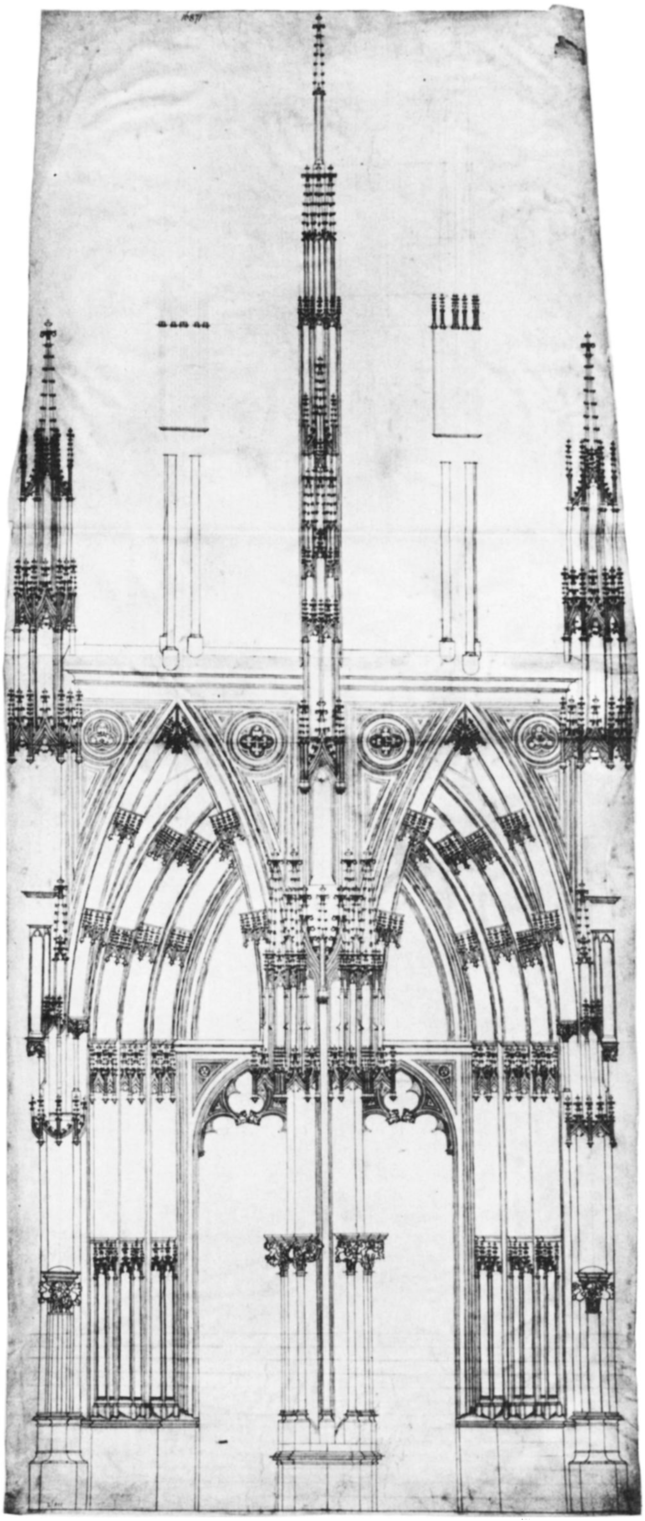

Fig. 24. Regensburg cathedral, drawing for entrance hall (Vienna Akademie).

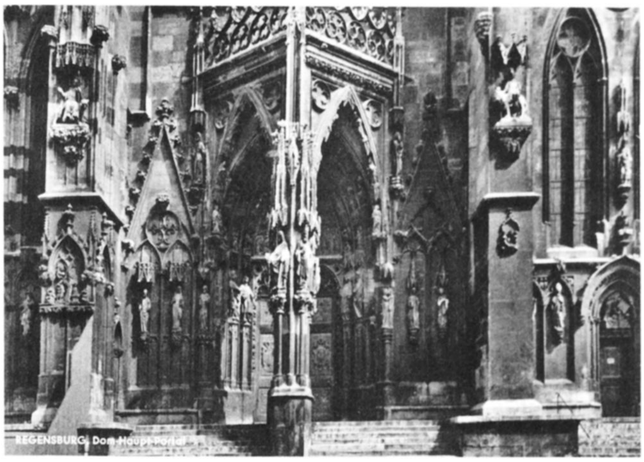

Fig. 25. Regensburg cathedral, entrance hall.

core with attached columns. This core expands into open work through the use of a second equilateral triangle topped by an expanding cornice which supports the upper work shown full face and in two views corresponding exactly to a simple projection. But the decorative arches are still simply halved to indicate their recession in space. The plan itself, which stresses the frontal view, may have been instrumental in the decision to turn the structure 30°, thus uniting one of its sides with the wall. Therefore only five faces of the hexagonal body are visible—a fact which decreases the lightness and elegance of the structure even more.

THE SHOW PLAN

The most impressive elevations of the Middle Ages were designed for many reasons, such as the architect's need to convince the authorities of the validity of his project, the need to raise money through the exhibition of a finished and detailed drawing, competitions, and the frequent need to facilitate the choice between several possible designs during construction.

The last of these reasons is responsible for the plan for an entrance hall from the Roritzer workshop. The Roritzer family, consisting of Wentzel (ca. 1350–1419), Konrad (ca. 1410–1475), and his son Matthaeus, was mainly involved with the lodge in Regensburg. Perhaps inspired by a similar solution in Erfurt, Konrad erected the entrance hall for the cathedral between 1456 and 1459. The impractical design is based on a triangle measuring 30×21×21 feet (Fig. 25). The elevation (Vienna, ABK 16871) is almost certainly a show plan made after the construction of the arches. At that time a decision as to the decoration of the top had to be taken (Fig. 24). Roritzer or his follower suggested pinnacles arranged in such a manner that their height, viewed from a distance, would echo the ground plan exactly. But even while the drawing was in process, doubts as to the elegance of the solution occurred. Instead of the modular approach which would have placed two of the finials over the arches, a more visual solution was adopted in which the central and the outer finials were shortened and connected by a dynamic horizontal banister whose circles repeat the relief circles below.

Several trends emerging from this plan must be mentioned briefly. The two-dimensional modular solution of the top indicates the increasingly important rôle of plans in the shaping of solutions. The most interesting aspect of the plan lies in the fact that it seems to be an accurate projection. In contrast to the plan for the "Schnegg" in Constance, the arch of the receding planes is no longer cut but simply foreshortened. This design thus becomes an exact frontal view of the presumably already extant work, and thus an elevation in the modern sense of the word. The ability to project diagonals correctly onto a plane presupposes the ability to do the reverse with equal ease. The plan confronts us with the existence of a theory of projection which seems to have been codified only later. The "secret" of the masons was not only modular progression but also the art of projection, especially onto curved surfaces. In this connection it is interesting to recall that Konrad Roritzer's son Matthaeus published his rudimentary *Püchlein der fialen gerechtikait* in 1486. There is good reason to believe that the Roritzer family did not understand the full implications of a complete projection system whose complexity I hope to discuss at a later date.

THE DYNAMIC PLAN

Late Gothic posed the ultimate challenge for the ability of the architect to create drawings which would be close to the limits of the interpretative abilities of his own colleagues. Roughly from 1450 to 1550 church furniture as pulpits, baptismal fonts, and tabernacles as well as rib-systems were created in imitation of wood. These *ersatz* "branches" could range from simple "twigs" to pieces cut in such complex swinging patterns that the stonecutting became extremely complex and the outer limits of stress possible for stone were reached. To bring the process to its logical fruition, intertwined tree trunks, branches, twigs, and even leaves would finally emerge from the stone. The whole process of this almost surrealistic approach is highly sophisticated both from a psychological and technical point of view, especially when the "organic" nature of stone is treated geometrically.

I shall briefly concentrate on some basic problems of designing these tabernacles, though without being able to provide satisfactory descriptions, for the simple reason that our architectural vocabulary does not provide us with an adequate terminology. Thus the designs will have to speak for themselves. Figure 26 (Vienna, ABK 16.910) shows the stone core of either a tabernacle or, less likely, of a pulpit. This core, which is derived in all its details from the modular square, is accompanied by free-standing shafts which help to carry the cantilevered structure above (Fig. 29). The design is once more one of the rare preliminary sketches; but even so it shows a modular progression into fake spirals constructed from circles and their segments, the largest circle repeating in its diameter the side length of the original square. A completed plan for a similar *aedicula* is found in design 17.048 in the Vienna Academy (Fig. 27). These two plans give us the geometric progression in width; but they give no details of the intertwining and probably inflected arches above. This was done—once more on a modular basis—in the Vienna design numbered 16979 which may well show the development of the uppermost parts of a tabernacle with interconnected members framed at the lowest point by intertwining ogee arches (Fig. 28). A similar development is found in one of the tabernacles in the south transept of Frankfurt cathedral. One of many similar elevations of late fifteenth- and early sixteenth-century tabernacles is today in the Victoria and Albert Museum in London. It stems from southern Germany and shows a relatively simple structure, interesting for us because it gives both the elevation with a branch frieze and an abbreviated plan which would just barely have allowed for the erection of the structure (Fig. 29).

By about 1520 we find that the plans for even the most complex structures tended to be simplified, partially because the architects and masons had handled similar problems before and more important, I think, because Renaissance designs were beginning to compete with the Gothic formal vocabulary.

VAULT-PATTERNS AND CUTOUTS

Among the material discussed about 200 designs of the fifteenth century consist in cutouts. A series of vault patterns beginning with the simplest solutions for a country church to complex rib patterns for buildings of varying proportions were usually impressed on paper with a sharp point and then cut out by an assistant. Thus the rib design stands out with extreme clarity and the page can be bent to give a three-dimensional effect. The same process was used for tracery patterns (Fig. 30). Though drawn reasonably exactly (as can be seen from the blind lines visible in the originals), the cutting was usually not very competent. Pages 187–188 from the Vienna Sketchbook provide two standard examples of a vault and of tracery. These cutouts were helpful in the workshop since they could be bent and thus give a didactic idea of the behaviour of—for instance—diagonals on a cylinder. But I would assume that they were

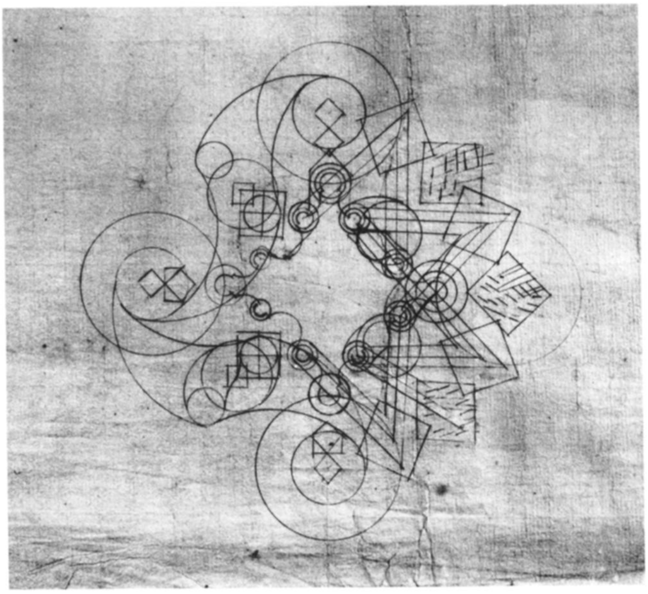

Fig. 26. Initial check for a tabernacle (Vienna Akademie).

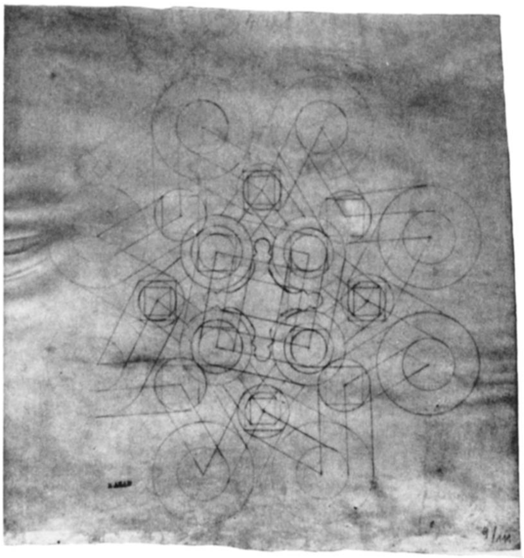

Fig. 27. Completed modular plan for a tabernacle (Vienna Akademie).

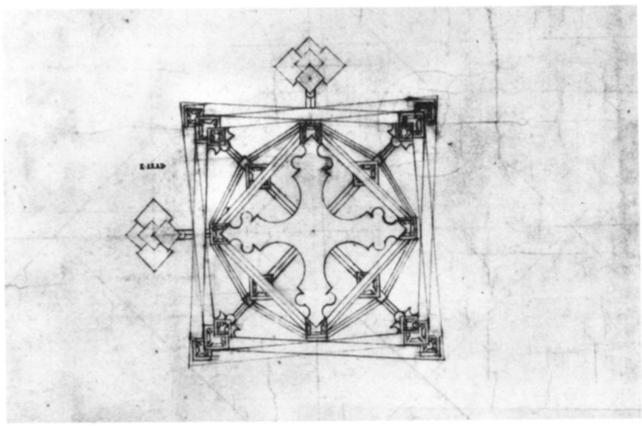

Fig. 28. Crowning element for a tabernacle (Vienna Akademie).

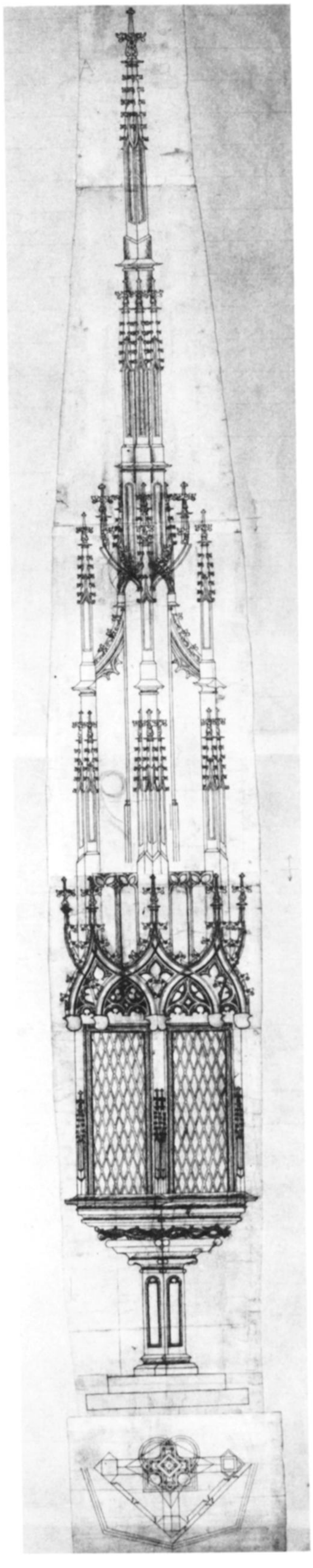

Fig. 29. Plan and elevation for a tabernacle (London, Victoria and Albert Museum).

mainly destined for clients who, through them, would gain a layman's impression of the vault, tracery, and gable elevation. Thus he could decide which of these designs, both from the point of view of price and form, would be the most suitable for a specific commission. These cutouts must, in my opinion, be compared with present-day contractors' brochures containing illustrations of doors, windows, fixtures, roof forms, etc. on which the prospective client will be able to base his decision. Many of these designs are standard late Gothic. The one illustrated here can be found realized approximately in the church of Gärtringen which was completed in 1496.

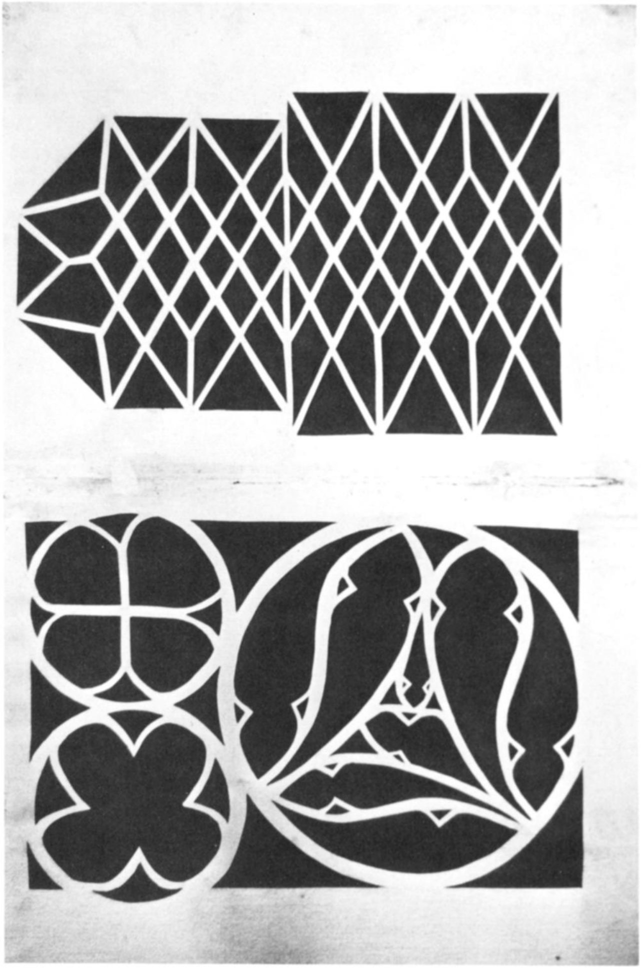

Fig. 30. Cutouts for tracery and vault patterns (Vienna, Albertina).

FANTASTIC PLANS

Of a series of Gothic architectural fantasies the small paper plan in the Akademie der bildenden Künste (No. 16889) comes perhaps closest to the strange but logical structures described by mediaeval poets such as the Younger Titurel, Chaucer, and in Lydgates *Temple of Glass*[30] (Fig. 31). It is true that from the end of the fourteenth century onward we find designs for structures and church furniture in which the physical properties of stone were pushed to the limits. One might think of the plan and fragmentary elevation destined perhaps for the tomb of St. Adalbert in St. Vitus in Prague by Peter Parler, of the cantilevered St. Lawrence portal of Strasbourg, the tabernacles of Ulm, of St. Lawrence in Nuremberg, of Frankfurt cathedral, of Pilgram's pulpit in Vienna and especially of the St. Severus font in Erfurt or a similar font in the cathedral of Regensburg. The openwork vault in the Capilla del Condestable in Burgos is topped only by suspended rib-branches. The dynamic interlocked systems of ribs and stone twigs in the Frauenkirche of Ingolstadt are bewildering. But an actual realization of the pentagon-hexagon structure seen in our plan seems well-nigh impossible. According to the usual practice of design seen in the cross sections through the stories of the tower of St. Stephen (Fig. 16), the inner pentagons and the two inscribed hexagons whose sizes were determined by the usual process, are indicated as being supported by ribs only. There is of course the possibility that we are dealing in fact with a complex "ambulatory" surrounding three steeply rising independent structures. But even then the practical use of such an arrangement would be difficult to imagine beyond the most likely interpretation of the design as an idea for a calvary, containing three small chapels connected by an ambulatory. Whatever the building might have been, the most important consideration remains the fact that we here enter into an era in which all the basic principles of planning had been tried out. It is between 1450 and 1520 that the architects felt constrained to push the experimentation with basic formulae so far that Gothic theory collapsed before the more rational approach of the Renaissance. The sudden switch of Benedikt Ried's shop from most highly complex late Gothic formal vocabulary, which Ried had mastered completely, to a relatively primitive interpretation of the new Renaissance style, fits this train of thought completely.

30. For a hypothetical plan of the temple of the Grail see P. Frankl, *The Gothic* (Princeton, 1960), p. 191ff. and Fig. 23. A rather complex plan in Stuttgart, Town Archives, Fragment 2, seems to have been destined for the tomb of St. Adalbert in St. Vitus, Prague. See O. Kletzl, "Planfragmente," p. 50ff., Figs. 4, 5 and Pl. IV. For complex late Gothic structures see P. Frankl, *Gothic Architecture* (Baltimore, 1962): Strasbourg St. Lawrence Portal, 1495–1505 (Pl. 143), Burgos, 1482–1494 (Pl. 146), and for tabernacles, fonts, and complex vaults plates 155–156 and 164–165. See also G. Fehr, *Benedikt Ried*, Figs. 6, 87. Many plans for strangely shaped structures are preserved. If a plan for Roritzer's Regensburg porch had survived it might have been difficult to interpret it correctly assuming that the porch had disappeared, and we cannot completely exclude the possibility that the plan here discussed was not in fact realized.

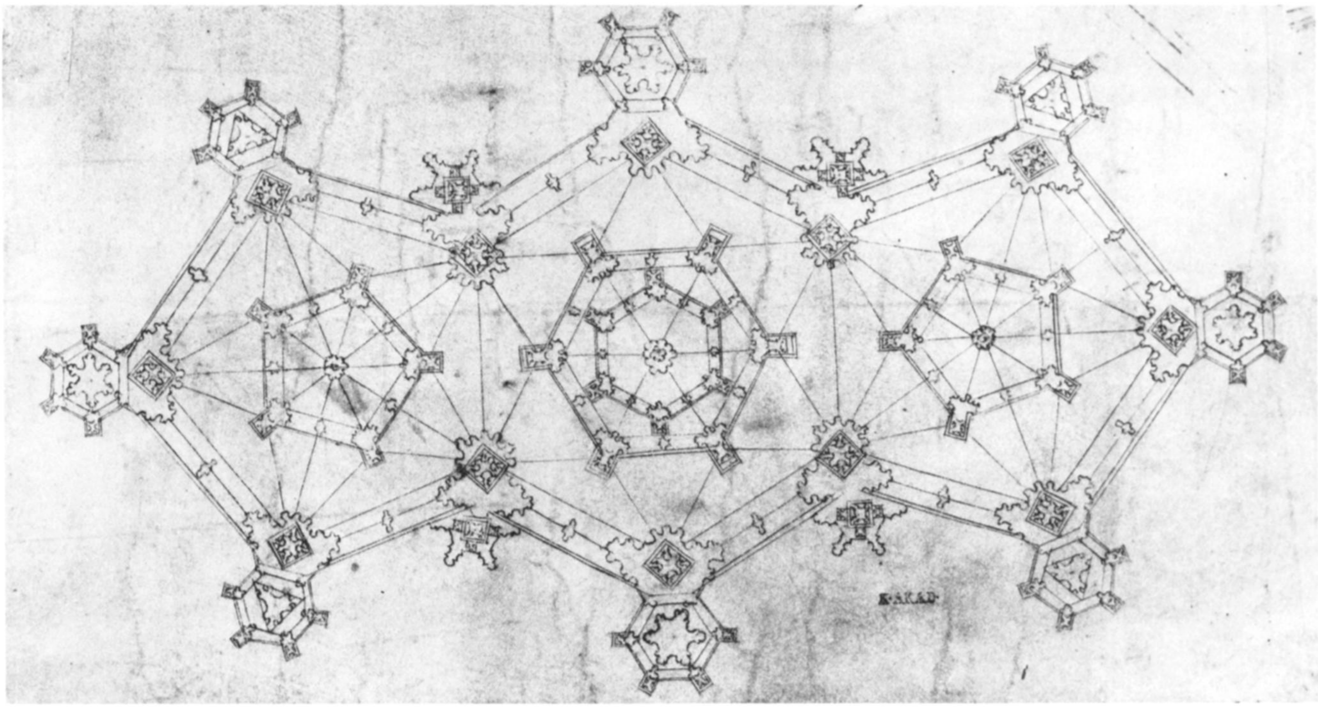

Fig. 31. Fantastic plan (?) (Vienna Akademie).

THE MEMORIAL SKETCH

We cannot end this discussion of Gothic plans without mentioning the memorial design, which ranges from rough records of completed structures in personal sketchbooks, often destined for publication, to Cesare Cesariano's woodcuts of Milan cathedral of 1521. The large woodcut portraying Strasbourg cathedral as "Das acht wunder der Welt" published in 1548 by Conrad Morant of Basel, burgher of Strasbourg "dem lieben Vatterland zuo lob, unnd allen werckmeistern Teutscher Nation zuo besonderm Wolgefallen" is the last mediaeval expression of architectural memorabilia destined to propagate a specific design.[31] Hans Böblinger's pen and ink view of the Hospital Church of Esslingen which had been completed in 1494 is the most engaging of these examples (Fig. 32).[32] In the inscription "Hanns Beblinger" states that the building was made by his father "Matheus" in Esslingen and that he, Hanns, copied it as it stood in the year 1501. The drawing typifies the pride of the family which had—among other projects—been in charge of the construction of the Frauenkirche in Esslingen and of the planning of the Ulm tower in 1482. Hanns himself is seen looking out of the attic window, holding a measuring rod, attesting thus personally to the accuracy of the drawing. The style would indicate that it was destined to serve as a model for an engraving, an intention which would not be surprising at a time when engravings of tabernacles, arch details, decorative patterns for doors, stalls, and church furniture as monstrances, were being circulated widely and appear glued into architectural sketchbooks.[33]

I shall at a later date discuss the most masterful of these sharply delineated views destined for printing. It represents Christ on the Mount of Olives, and is in the Ulm Museum (Fig. 33). It measures 42 × 108 cm. The precise technique and the inscription makes an attribution to Hanns Böblinger almost certain. But here he worked with a painter who did the figures, a practice frequently found in show-designs of the late fifteenth and early sixteenth centuries. As the inscription states, the monument was planned and carved by "matheij boblinger von esslingen gen Ulm." Unfortunately the sophisticated openwork octagon over the figures was destroyed to make room for a parade ground.

31. See P. Frankl, *The Gothic*, Figs. 32, 55.

32. See Freiberg and Hainisch, *Gotische Baurisse*, No. 65, and Hermann Egger, *Architektonische Handzeichnungen alter Meister* (Vienna, 1910), Pl. VI; for the Böblinger family: P. Frankl, *The Gothic*, pp. 134, 148. O. Kletzl, "Planfragmente," pp. 70, 76, 119, 126, H. Tietze, "Aus der Wiener Bauhütte von St. Stephan," *Jahrbuch der kunsthistorischen Sammlungen in Wien*, N.F. V (1931), p. 171ff. The text states: "Den baw hat gemachet matheus Beblinger mein vatter zu Esslingenn im spittal dass han ich Hannss beblinger abgemacht wie es da statt in dem jar 1501."

33. See K. Rathe, *Ein Architektur-Musterbuch*, p. 667ff.

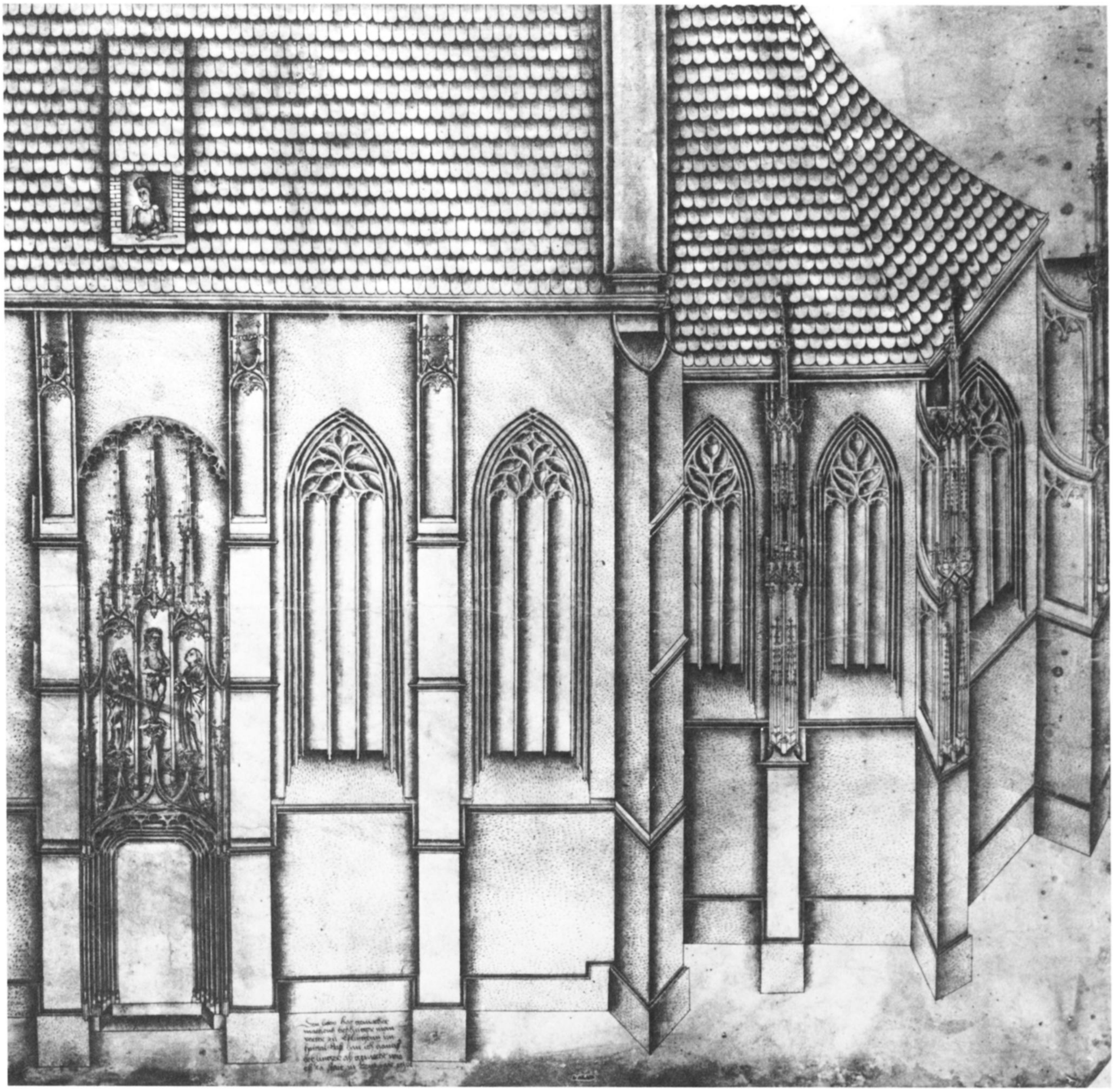

Fig. 32. Hans Böblinger. The Hospital church of Esslingen (Vienna Akademie).

PRELIMINARY CONCLUSIONS

The very large number of late Gothic plans which cover all the phases of construction from the initial concept for a building to placement charts and memorial sketches makes it more than likely that extensive, careful, and detailed planning accompanied the erection of large structures at least from the beginning of the thirteenth century onward. The geometric canon was at first based on modular addition and then replaced by modular inscription or rotation, thus producing proportions containing irrational numbers. In addition to the square and the two basic triangles, rotating polygons and circles inscribed in squares were used. The standard rectangle as well as the golden section were geometrically constructed at least from the twelfth century onward.

The geometric systems had many levels. They governed the making of templates and thus the mason's chisel. They provided the grid on which plans, elevations, and details evolved and thus also the means to re-experience the creative process at will.

Each of the systems produced a logical, repeatable, and reasonably flexible approach, controlled by the unchanging laws of geometric progression. Thus planning also reflected the absolute order of the world as represented in cosmological schemes showing inscribed figures representing the orderly perfection of the universe.[34]

The deepest secret of the masons at a time when geometry governed the design is one of which they themselves were only instinctively aware. For the basic laws governing these proportions, and according to Thierry of Chartres and others, the universe may in fact turn out to be an a priori geometry governing modular sequences in nature.

In his introduction to the *Lives* Giorgio Vasari described Gothic in chapter III, paragraph 28, as monstrous and barbaric, devoid of order, and so on, and goes on to say that the architects "threw the works that they built out of proportion." We have only recently begun to realize the extent to which this statement is refuted by surviving evidence.

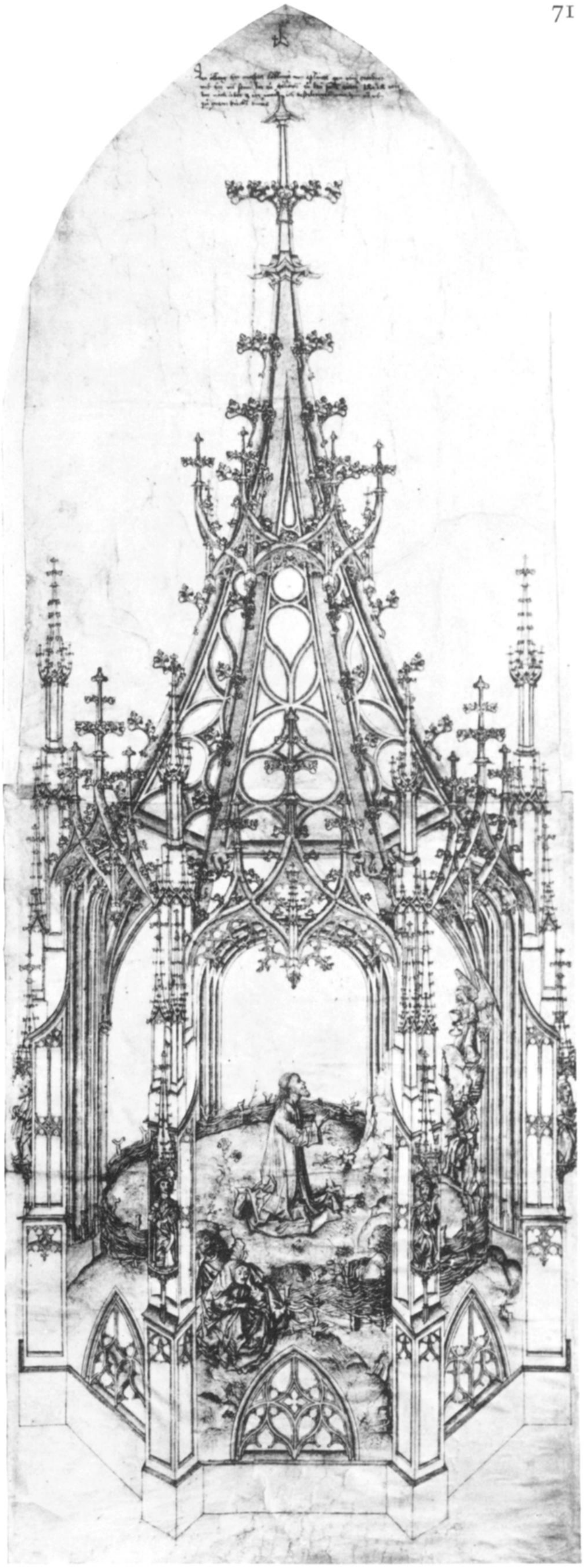

Fig. 33. The Mount of Olives in Ulm, probably Hans Böblinger (Ulm Museum).

34. The inscribed square is for instance used in Bede's *De natura rerum*, Vienna, State Library, mss. lat.387. See S. Ferber, "Crucifixion Iconography in a Group of Carolingian Ivory Plaques," *Art Bulletin*, XLVIII (1966), 323–334, Fig. 1. The use of the square in the cosmological window of Lausanne discussed in this essay may be related to these cosmographic schemata. I should be thankful to receive any information on mediaeval plans, fragments of plans, or models which may be in private collections.