



Taylor & Francis
Taylor & Francis Group



college art association

"Ars Sine Scientia Nihil Est" Gothic Theory of Architecture at the Cathedral of Milan

Author(s): James S. Ackerman

Source: *The Art Bulletin*, Vol. 31, No. 2 (Jun., 1949), pp. 84-111

Published by: College Art Association

Stable URL: <http://www.jstor.org/stable/3047224>

Accessed: 10-11-2015 10:55 UTC

Your use of the JSTOR archive indicates your acceptance of the Terms & Conditions of Use, available at <http://www.jstor.org/page/info/about/policies/terms.jsp>

JSTOR is a not-for-profit service that helps scholars, researchers, and students discover, use, and build upon a wide range of content in a trusted digital archive. We use information technology and tools to increase productivity and facilitate new forms of scholarship. For more information about JSTOR, please contact support@jstor.org.



Taylor & Francis, Ltd. and College Art Association are collaborating with JSTOR to digitize, preserve and extend access to *The Art Bulletin*.

<http://www.jstor.org>



Taylor & Francis
Taylor & Francis Group



"Ars Sine Scientia Nihil Est" Gothic Theory of Architecture at the Cathedral of Milan

Author(s): James S. Ackerman

Source: *The Art Bulletin*, Vol. 31, No. 2 (Jun., 1949), pp. 84-111

Published by: College Art Association

Stable URL: <http://www.jstor.org/stable/3047224>

Accessed: 10-11-2015 10:55 UTC

Your use of the JSTOR archive indicates your acceptance of the Terms & Conditions of Use, available at <http://www.jstor.org/page/info/about/policies/terms.jsp>

JSTOR is a not-for-profit service that helps scholars, researchers, and students discover, use, and build upon a wide range of content in a trusted digital archive. We use information technology and tools to increase productivity and facilitate new forms of scholarship. For more information about JSTOR, please contact support@jstor.org.



Taylor & Francis, Ltd. and College Art Association are collaborating with JSTOR to digitize, preserve and extend access to *The Art Bulletin*.

<http://www.jstor.org>

“ARS SINE SCIENTIA NIHIL EST”

GOTHIC THEORY OF ARCHITECTURE AT THE CATHEDRAL OF MILAN*

JAMES S. ACKERMAN

Il convient de constater d'abord qu'il est impossible de séparer la forme de l'architecture du XIII siècle de sa structure; tout membre de cette architecture est la conséquence d'un besoin de la structure, comme dans le genre végétal et animal il n'est pas un phénomène, un appendice qui ne soit le produit d'une nécessité organique. . . . Cette forme n'est pas le résultat d'un caprice, puisqu'elle n'est que l'expression décorée, si vous voulez, de la structure.

—E. Viollet-le-Duc, *Entretiens sur l'architecture*, Paris, 1863, I, pp. 284, 287

THE opinion of Viollet-le-Duc, summarized in these words, typifies an approach to the interpretation of Gothic architecture which has held great appeal for the modern student. The evident harmony of this approach with the “functional” spirit of a nascent style of contemporary architecture partially explains its success. It is more significant, however, that the conflicts created in our aesthetic responses by the scientific and mechanical psyche of our age are here neatly resolved by an interpretation which is mechanistic, which explains cultural phenomena in terms of irreducible and demonstrable fact. Yet, granting that by this means Gothic architecture becomes in a sense more intelligible to the modern mind, it remains to be seen whether this intelligibility is not gained at the cost of understanding. Our problem is to determine whether a type of logic which is so distinctly tinged with the flavor of experimental science fortuitously illuminates a mediaeval creative process, or whether it forces us to see through a glass, darkly.

A considerable literature already exists on the subject of “Gothic Rationalism,” as this view is sometimes called. In France, for example, the particular views of Viollet-le-Duc have been assaulted by Pol Abraham and others, and in turn stoutly defended.¹ Much effort has been spent in the attempt to prove, by the study of extant monuments, that certain elements believed by Viollet-le-Duc to be essential to the structural skeleton are in reality inorganic. This controversy has concentrated on the problem of the function of the rib in Gothic vaulting, but in spite of bringing to bear upon the question the most formidable tools of modern engineering, the arguments on both sides have remained inconclusive. The failure is largely methodological, for in their painstaking analysis of such particular elements, the adversaries of Rationalism become themselves enmeshed in the web of inductive scientific technique. They have furthermore failed to appreciate that our understanding of Gothic architecture would not be substantially enriched by the destruction of a nineteenth century interpretation. If Rationalism is proven inadequate, it is the responsibility of the

* This study is based on a paper delivered at the thirty-sixth annual meeting of the College Art Association in January 1948. I wish to express my gratitude to Professor Richard Krautheimer for his generous assistance and criticism, and to Dr. Erwin Panofsky, who directed me to the Milan texts,

for clarifying some difficult passages.

1. The most comprehensive criticism of Viollet-le-Duc is made in Pol Abraham, *Viollet-le-Duc et le rationalisme médiéval*, Paris, 1934, and a digest bearing the same title in *Bulletin Monumental*, XCIII, 1934, pp. 69-88.

contemporary historian to search for data which will aid in the formation of a view better suited to both the facts and the spirit of Gothic architecture.

The problem we have posed is to discover whether or not the attempt to derive the form of Gothic architecture from its structure is justified, and if not, to suggest a more illuminating approach. The method of procedure which suggests itself is to some degree implicit in our criticism of Rationalism, for if we wish to avoid the imposition of modern criteria upon the Gothic style, we are bound to seek for Gothic criteria. This involves a reconstruction of the specific intentions of the Gothic architect with respect to the form, the purpose, and structure of his building. Since the analysis of remaining monuments provides insufficient evidence for this task, we must turn, not to the works, but to the men who created them, whose aims are most concretely revealed among the textual remains of the period.²

It is doubtful whether a search of mediaeval sources will ever discover such explicit expositions of the practice of architecture as are found in the treatises produced from the mid-fifteenth century on. The claim of the architect to be placed among creative artists, his desire to formulate and spread a doctrine of architecture, is to a degree a sign of the Renaissance. Prior to the fifteenth century, writings which concern architecture are few in number and widely divergent in nature, and are for the most part of little assistance in reconstructing the concepts of the architect in relation to structure. However, evidence which bears directly on the problem of Gothic theory and practice is found in startling abundance in the late fourteenth century records of an Italian architectural workshop: the Annals of the building of Milan Cathedral. It is surprising that a source of this nature should produce the kind of material for which we are seeking. Mediaeval workshop records ordinarily are concerned only with matters of supply, finance, and employment. In general, this is also the case at Milan, and the exceptions which will be considered here, representing only a small portion of the published records, are passages resulting from the unusual circumstances of the construction.³ The constant changes of master-builders, recurrent indecisions as to procedure, and frequent errors in practice which hamper the progress of the Cathedral are reflected in the records in the form of criticisms and debates which give expression to a variety of theoretical positions. Had the program of construction been better organized, we might have had fewer sources of this nature and, by way of compensation, a more admirable cathedral.

The foundation of the Cathedral of Milan in 1386 signaled Lombardy's emergence from an artistic eclipse which began at the close of the Romanesque period.⁴ The political instability which had impoverished the duchy during the thirteenth and fourteenth centuries was brought to an end by Gian Galeazzo Visconti (1347-1402), whose military campaigns temporarily annexed to Lombardy a large portion of Venetian territory, most of Emilia, and a part of Tuscany. The revival of monumental architecture may be attributed both to the ambitious personality of the Duke, and to the increase in wealth and security which resulted from political consolidation. Within ten years

2. The validity of the textual approach to the problem of Rationalism has been ably proved by George Kubler in "A Late Gothic Computation of Rib Vault Thrusts," *Gazette des Beaux-Arts*, xxvi, 1944 (Mélanges Henri Focillon), pp. 135-148 (which includes a valuable digest of the Rationalist controversy). This study of a tract on structural problems by the sixteenth century Spanish architect, Rodrigo Gil de Hontañón, reveals a theory of vault construction which is different from those of both Viollet-le-Duc and his opposition. The mathematical systems employed by Rodrigo in the calculation of thrusts are perhaps too advanced to be regarded as part of the mediaeval tradition, but his testimony is none the less valuable as an essential link in the reconstruction of Gothic theory of architecture.

3. The eight-volume edition of the records of the Cathedral,

published by its administration under the title: *Annali della fabbrica del Duomo di Milano dall' origine fino al presente*, Milan, 1877-1885, makes available a wealth of material which is almost unique in mediaeval architectural studies. Comparison with the earlier publication of Ambrogio Nava, *Memorie e documenti storici intorno all' origine, alle vicende ed ai riti del Duomo di Milano*, Milan, 1854, indicates that the *Annali* are not complete or consistently accurate, but it may be assumed that they include the great majority of remaining documents.

4. For the history and a critical bibliography of the Cathedral, see Camillo Boito, *Il Duomo di Milano e i disegni per la sua facciata*, Milan, 1889. Stylistic criticism and interpretation of textual sources is found in Luca Beltrami, *Per la facciata del Duomo di Milano*, Milan, 1887.

of the foundation of the Cathedral, three major architectural projects were undertaken in the Milan area: the reconstruction of Monza Cathedral,⁵ the Certosa of Pavia (a private project of the Duke),⁶ and the Cathedral at Como.⁷

The new architectural campaigns called for building on a scale calculated to rival the largest Gothic cathedrals of western Europe, a goal which was not destined to be achieved easily by a society which had so recently emerged from two centuries of cultural obscurity. The provincial character of the thirteenth and fourteenth century architectural tradition of Lombardy in itself suggests that the architects of Gian Galeazzo Visconti were poorly prepared for a renaissance of monumental architecture.

A conservative Gothic church style had developed in Lombardy almost exclusively under the sponsorship of the monastic orders. The style is essentially a compromise between the Romanesque cathedrals of the region and the French Cistercian forms introduced into central Italy in the twelfth century.⁸ There is no evidence of influence from contemporary developments in the architecture of western Europe. The flying buttress is rarely employed, fenestration remains limited, monumental sculpture is foresworn, and the exteriors are uniformly of unfaced brick. The style is modest to the point of poverty, and yet it developed an individuality which distinguishes it from monastic architecture elsewhere. A variety of the Cistercian plan which is typical of Lombardy is the arrangement of outer chapel-rows along the side aisles, as is seen in the example in Figure 2.⁹ This produces in effect, a five-aisle arrangement in the western arm which has, as will appear later, an influence on the planning of Milan Cathedral. The most distinctive feature of the style is the lively decora-

5. See A. G. Meyer, *Lombardische Denkmäler des vierzehnten Jahrhunderts*, 1893, pp. 112ff. An inscription on the cornerstone dates the completion of the façade in 1396, and names the master, Matheus de Camplione.

6. The Certosa was ceremoniously founded by Gian Galeazzo Visconti and his sons on August 27, 1396 (see Luca Beltrami, *Storia documentata della Certosa di Pavia*, Milan, 1869, pp. 62f., 140). Only the foundations of the church were completed before the second half of the fifteenth century.

7. The rebuilding of an older Como Cathedral was probably started in 1396, but no building records remain from the fourteenth century (see D. S. Monti, *La Cattedrale di Como*, Como, 1897, pp. 27-32). As at the Certosa, progress on the building was virtually halted between the death of Gian Galeazzo and the commencement of the Sforza rule in 1450.

8. Although this "Lombard Gothic" style has numerous features which differentiate it from contemporaneous architecture in northern Italy, its individuality has not been recognized. Perhaps because of the provincial character and dilapidated condition of the few remaining examples of the style, it has been by-passed by recent scholarship. There was, however, a flurry of interest in this field during the nineteenth century, which, rising and fading with the Gothic Revival movement, maintained a uniformly superficial approach. Some consideration of Lombard Gothic architecture may be found in the following: Thomas Hope, *An Historical Essay on Architecture*, London, 1835; R. Willis, *Remarks on the Architecture of the Middle Ages, Especially of Italy*, Cambridge, 1835; Amico Ricci, *Storia dell'architettura in Italia*, Modena, 1857-1859; Franz Kugler, *Geschichte der Baukunst*, Stuttgart, 1856-1859; W. Lübke, "Reisenotizen über die mittelalterlichen Kunstwerke in Italien," *Mitth. der Kaiserl. Königl. Centralcommission*, v, 1860, pp. 112-120, 134-140, 160-173; Max Nohl, *Tagebuch einer italienischen Reise*, Stuttgart, 1866; L. Gruner and F. Lose, *The Terra-cotta Architecture of North Italy*, London, 1867; George E. Street, *Brick and Marble in the Middle Ages*, London, 1855, 2nd ed., 1874; Carl Schnaase, *Geschichte der bildenden Künste*, v, Düsseldorf, 1876; Oscar Mothes, *Die Baukunst des Mittelalters in Italien*, Jena, 1884; L. Runge, *Beiträge zur Kenntniss der Backstein-Architektur Italiens*, Berlin, 1885; Heinrich Strack, *Ziegelbauwerke des Mittelalters*

und der Renaissance in Italien, Berlin, 1889. A. Kingsley Porter's *Lombard Architecture*, New Haven, 1917, treats a few Gothic monuments which originated in the Romanesque period.

The area of the style spreads westward from Milan to Brescia and Mantua, and is bordered by the Alps to the north, and Piacenza to the south. Genoa, Bologna, and Venice are centers of styles clearly separable from that of Lombardy. The chronological limits, however, are more difficult to determine, and the paucity of reliable dates makes even the tracing of a stylistic development impossible. All but a few of the remaining monuments appear to have originated in the century 1280-1380, while the course of the preceding century remains uncharted.

The monastic plan-type of the Lombard Gothic church is evidently imported from Tuscany, while the façades reflect the local Romanesque style of San Michele in Pavia, Modena, Piacenza, etc. The cubic Romanesque bell-tower of northern Italy is transformed into a delicate and open form capitalizing on terracotta ornament, as seen at the "Torazzo" of Cremona Cathedral, of 1284, and the mid-fourteenth century tower of San Gottardo in Milan. At Chiaravalle Milanese this type is employed over the crossing of an earlier church. The Gothic forms of central France imported into north Italy at San Andrea in Vercelli in 1219 (flying buttress, two-tower façade, etc.) apparently had little influence on the architecture of the region.

Besides Santa Maria del Carmine in Pavia, which is illustrated here, the Lombard Gothic type is well represented in San Agostino and San Luca in Cremona; San Bassiano and San Francesco in Lodi; San Francesco in Pavia; Santa Maria del Carmine, San Francesco, and San Antonio in Piacenza (the latter with a unique western porch); San Francesco in Vercelli, and numerous village churches. Remaining examples in the Milan area—among them San Giovanni in Conca, San Marco, and Santa Maria in Strada in Monza—are largely defaced by nineteenth century reconstruction.

9. Although this plan-type is peculiarly Lombard, it occasionally appears elsewhere, as at San Fortunato in Todì, a Tuscan church of the early fourteenth century (see W. Krönig, "Hallenkirchen in Mittelitalien," *Kunstgesch. Jahrbuch der Bibl. Herziana*, 11, 1938, pp. 78ff.).

tive sense exercised in the rich brick-and-terracotta façades, and the highly coloristic bell- and crossing-towers. Although both these features manifest the parentage of the Lombard Romanesque style of the twelfth century, they undergo a development in the Gothic period to a point of definite individuality. On the whole, however, the imagination of the Gothic builder is channeled into the decorative aspects of his art, and there is little evidence of technical growth during the thirteenth and fourteenth centuries.

A well-preserved and typical Lombard Gothic church is the Carmine in Pavia (Figs. 1, 2). The chapel-rows give the plan a rectangular form and produce a façade of unusual breadth. Pinacles and terracotta ornaments enliven the façade, which contrasts to the ascetic severity of the interior, where the nave walls are relieved only by small oculi in the clerestory. The slight wall-buttresses which we see on the façade are also employed to support the nave along the sides. Setting aside the ornamental features of this building, there is nothing to suggest that it belongs to the end of the fourteenth century rather than to the end of the twelfth.¹⁰

It proved in practice almost impossible to adopt the Lombard Gothic idiom to the structural and aesthetic requirements of the new programs sponsored by the Duke. The failure of the tradition is reflected in the stylistic confusion of the Visconti monuments. Milan Cathedral leans toward the northern Gothic, Monza toward the Tuscan, Como toward the Venetian, and the Certosa of Pavia adds Romanesque revival and Florentine Renaissance elements to a fanciful Gothic core. Thus the Lombard architects of the end of the fourteenth century chose the only possible course: they borrowed their style from any and every foreign source. Tradition died hard, however, and the submission to alien forms was made unwillingly. The French and German masters who were hired to aid the architects of Milan Cathedral were bitterly received and poorly treated. The history of the Cathedral is one of constant wrangling between local and foreign builders.

Evidently the inadequacy of the provincial tradition was not immediately apparent to the architects of Milan Cathedral. It seems, in fact, to have been their original intention to build without assistance from the north. The building council appointed in 1386 confidently produced its own designs, and broke ground shortly after the Pope granted a charter for the construction. The essential lines of the foundations were established before the question of foreign advisors came under consideration. The first of these to be appointed was a Frenchman, Nicolas de Bonaventure, who became a privileged engineer of the Cathedral in July of 1389, three years after the foundation.¹¹ This change in policy was evidently motivated by circumstances which forced the council or the lay deputies to admit that the self-confidence with which the project had been commenced was unwarranted. There were already faults in the foundations, and the inability to determine a pier design constituted an obstacle to progress.¹² There was a pressing need for the expert assistance of Nicolas. On the basis of this information there may be some justice in assuming that the northern Gothic character of the Cathedral began to take form only after the arrival of the Frenchman, and that the initial plan was conceived in the Lombard Gothic style. We shall introduce in the course of this study certain documents in support of this assumption, although circumstantial evidence alone is persuasive. The possibility that the council began its original project in imitation of northern Gothic church architecture is rendered unlikely both by its manifest ignorance of northern art, and by the nature of the Cathedral plan itself. The first foreigner was hired with evident reluctance, and only when it became apparent that the problems involved in building on such a scale could not all be solved by Lombard Gothic masters. The appointment of a Frenchman was motivated, not by admiration for French architecture, but by respect for French engineering. That a dose of

10. The church has been traditionally assigned a date of 1373 (see A. Ricci, *Storia*, II, 397; Willis, *Remarks*, p. 165). Lübke's suggestion of 1325 ("Reisenotizen," pp. 161ff.), is unsupported. The decorative style of the façade gives more credence to the later date.

11. *Annali*, I, 25 (6 July).

12. Certain features of the foundations were criticized in a conference in March 1388 (*ibid.*, I, 19). The design for the piers which was hurriedly adopted (see Boito, *Il Duomo*, p. 99) had to be abandoned in the following two years.

northern stylistic concepts had to be administered with the doctoring was clearly galling to the Milanese and, like many of his successors, Nicolas was dismissed within a year.¹³

A remarkable document remains from the period of Nicolas' visit. It is a sheet of sketches which has on the recto a plan of the Cathedral with the projected section of the nave, including measurements of certain elevations, and on the verso an elevation of the exterior of the sacristies (Figs. 5, 6). The author is Antonio di Vincenzo, a Bolognese architect who had been sent to Milan to make notes for his future work at San Petronio. The date of these drawings is 1390.¹⁴ They constitute a primary source for the history of the Cathedral, revealing in the plan, the character of the foundations laid before the onset of foreign influence, as well as indicating future procedure in the section and elevation. Comparing this plan with that of the present Cathedral (Fig. 4), we find that the transept is one bay longer on either side, with flat terminations and an entrance in the northern arm.¹⁵ Its Romanesque character, a consistent theme in Lombard Gothic, is unmistakable.¹⁶

Since it was evidently the problem of erecting the piers which motivated the decision to enlist the aid of a Frenchman, Antonio's sketch may help us to understand the difficulties encountered by the Milanese. The crossing-piers, which the sketch and Antonio's notes represent as larger and more complex than the others, were originally the same size. This information comes from a notice of July 1390, at which time it was decided to make this alteration.¹⁷ Now, the lesser piers in Andrea's sketch are designed as a round core with four engaged shafts. A comparison with the present plan (Fig. 4) shows that this project was also altered. The pier design thus goes through three stages: first, all piers relatively thin; second, the crossing-piers enlarged; third, the lesser piers enlarged. It was possibly upon the insistence of the French architect that these alterations were made. The remarkable fact is that the Milanese were guilty of this great uncertainty concerning their supports at a time when the foundations were completed, and the massing of the church established. What the Rationalist would call the "skeleton" of the building was still in a state of flux! In this case, certainly, structural considerations did not determine the forms.

The proposed sacristy elevation (Fig. 6) in Antonio's sketch shows a decorative scheme and tracery which was closely followed in subsequent work on the Cathedral exterior. The distinctly northern flavor, reminding one somewhat of Strasbourg Cathedral, is in all likelihood the con-

13. *Annali*, I, 36 (31 July): "che si cassi maestro Nicola de' Bonaventuri, ingegnere della fabbrica, dal salario che gli si corrisponde, e lo si tolga intieramente dalle opere della stessa fabbrica."

14. The text accompanying the sketches reads:

- A: Nota che le nave pezoze sieno larghe piedi xxv e unze octo commentzando da mezo del pilastro al altro mezo e cosi sono posti tutti li pilastri per quadro. Note ch  li quatro pilastri grosi che sono in mezo la croxeria zo  la truna sono grosi piedi sette onze otto piliando tute le tetaze. Tutto al resto di li pilastri sono grosi piedi sette onze una.
 B: da mezo questo pilastro al altro mezo si  piedi L1 onze IIII.
 C: Piedi L1 onze IIII.
 D: Piedi xxv onze VIII.
 E: braza VI.
 F: braza III.
 G: braza X.
 L: braza XXXX per fino soto el capitulo.
 M: braza XXX milanese piliando el capitulo.
 N: va alta la cupola dal mezo braza CXIII.

A milanese braccio of this period measures about .595 meters. Since we know that the aisle bays measure 16 braccia and the nave bays, 32 braccia, we are able to transpose Antonio's Bolognese foot to roughly .369 meters. The "unze" or "onze" is analogous to our inch.

The text and the plates which accompany it have been taken from Boito, *Il Duomo*, pp. 106, 108. Both were copied by Luca Beltrami in the archives of San Petronio in Bologna, and published in *Raccolta Milanese*, December 1887, a periodical which I have been unable to find. Beltrami bases the

dating of the sketch on a notice in the records of San Petronio, according to which Antonio left Bologna for Milan in February 1390.

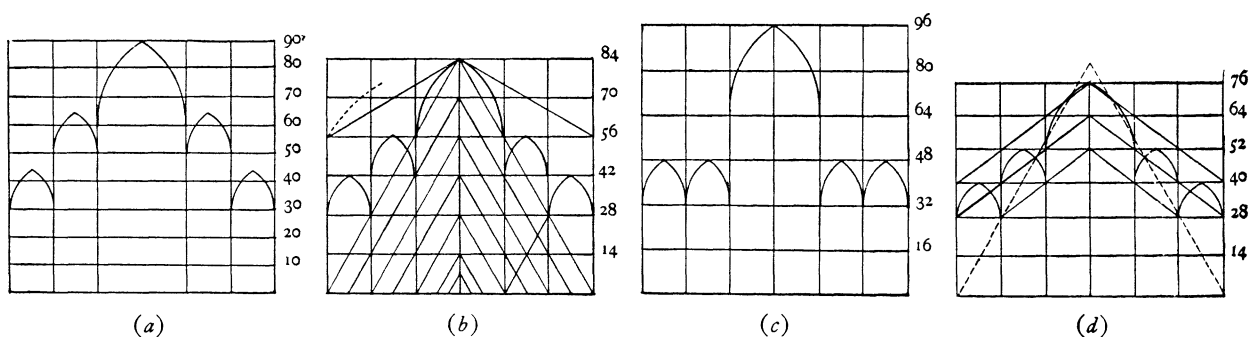
15. Boito's suggestion (*op. cit.*, p. 107) that Antonio was confused by scaffolding and rubble into adding two bays onto the transept is difficult to accept. The plan is executed with some care, and lacking further evidence on the early project, we can assume only that the additional bays were either in existence or under consideration in 1390. Antonio's omission of piers in the western portion of the nave is also intentional, for the erection of the bays nearest the entrance awaited the demolition of the fa ade of the ancient Cathedral (see Giulio Carotti, "Vicende del Duomo di Milano e della sua facciata," *Archivio storico dell' arte*, II, 1889, p. 118 and fig. 2).

16. I refer particularly to the Cathedral of Piacenza, where the relationships in plan of the principal portions of the building are strikingly similar to those in this sketch.

17. *Annali*, I, 36 (19 July): "Super sala reverendi domini archiepiscopi deliberaverunt quod illi quattuor pironi tiburii fabricae augmententur in grossitudine se ingrossentur per quartas tres in quadro, taliter quod sint in circuitu quartas 1 1/2 (sic—1 1/2?) plus aliis pironis." Although it is not specifically stated, it is reasonable to assume that at the time of this decision, the crossing-piers were of the same thickness as the lesser piers. The precise character of this change is unclear. The term "quarta" is frequently employed in the records as a unit of measurement, and may be equivalent to 1/4 braccio. Whatever its value, it is difficult to see how the increase in the circumference of the pier (if it is 1 1/2 quartas) can be exactly half of the increase in the "square" (3 quartas).

tribution of Nicolas de Bonaventure. That a decorative scheme of a quite different character was originally projected is clear from the present design of the lower portion of the interior wall of the north sacristy, which is executed in the style of a Lombard Gothic façade.¹⁸

In Antonio's delineation of the projected nave section, sufficient measurements are provided, although the drawing is not made to scale, to enable us to reconstruct the scheme with reasonable accuracy (*text figure a*, below). The letter *M* (the height of the wall piers) = 30 braccia; *L* (height of the side-aisle piers) = 40 braccia; *H* (height of the capitals of both major piers) = 10 braccia; *G* (distance of the nave impost from the capital) = 10 braccia, or 60 braccia from the ground.¹⁴ No measurement is provided for the height of the nave vaults. The measurements *E* and *F* are apparently extraneous to the problem of establishing the main lines of the design. Paul Frankl, in his analysis of this project, proposes that these figures represent a very simple device on the part of the designer: the employment of a basic unit of ten braccia for the establishment of the heights of various elements.¹⁹ Such a unit has a sound utilitarian purpose, for it is calculated to provide measurements which might be followed readily by a mason equipped only with a measuring stick (in this case, probably 5 braccia in length). Antonio's design, however, was in as tentative a state as that of the supports, because a year after the sketch was made, the Archbishop was asked to call a conference to decide on the "length of the pilasters, the height of the church, of the windows, doors and other things."²⁰ In terms of the "rational" interpretation of Gothic construction, it is inconceivable that the height of a structure should remain undetermined after the foundations had been completed, but this is the case at Milan. The section project seen by Antonio was only the first of five different solutions which are known to us. This inversion of what we would regard as logical method is not unique, and it proves to have been standard procedure at Milan to permit the Cathedral to grow haphazardly, without an ultimate aim. In consonance with this method, the piers were redesigned in their present form shortly after Andrea's visit, and their construction begun well before the height of the capitals had been fixed.



MILAN, CATHEDRAL. PROJECTS FOR DETERMINING HEIGHT OF NAVE, AISLES, PIERS, AND VAULTS TO BE ERECTED ON FOUNDATIONS 90 BRACCIA WIDE. (a) Project of 1390 employing units of 10 braccia, after sketch and notes by Antonio di Vincenzo. (b) Project of 1391 employing units of 14 braccia, within framework of equilateral triangles, after sketch by Gabriele Stornaloco. (c) Project of 1392 employing grid of squares, reconstructed from texts. Probably proposed by Heinrich Parler of Gmünd. (d) Project accepted in 1392 employing Stornaloco's project to a height of 28 braccia (dotted lines), and continuing with units of 12 braccia within framework of Pythagorean triangles, after specifications of Cathedral council.

As the piers grew, the problem of the nave section became, of course, increasingly pressing. The dissatisfaction with the simple but rather arbitrary scheme employing units of ten braccia may be traced to the criticisms of Annas de Firimburg, a German architect who succeeded Nicolas de Bonaventure. Annas evidently wanted to substitute one which had a more soundly established rationale,

18. See Boito, *Il Duomo*, plate 29, and Beltrami, *Per la facciata*, I, 29.

19. "The Secret of the Mediaeval Masons," *ART BULLETIN*, XXVII, 1945, pp. 51f. For a more detailed consideration of An-

tonio's design, and the subsequent solutions which are briefly considered here, I refer the reader to Dr. Frankl's excellent study, to which I have been greatly indebted.

20. *Annali*, I, 53 (24 August, 1391).

for he proposed that the section be designed within an equilateral triangle.²¹ The role of plane geometry in the building theory of the Gothic period will shortly become evident and, from the standpoint of this theory, its introduction at this point is a sign of great progress. In accepting the new scheme, however, the building council encountered a difficult problem. The height of an equilateral triangle is incommensurable, and its employment appeared to involve foregoing the advantages of simple, yardstick measurement which were secured by the earlier scheme. The solution of this dilemma was not in the province of an architect, and a mathematician named Gabriele Stornaloco was summoned from Piacenza in September 1391.²² On his return to Piacenza he submitted his opinion in a letter accompanied by a drawing (*figure b*).²³ The superiority of this project lies in the fact that it not only provides a framework of equilateral triangles, but coordinates this framework with a grid as simple as that of the earlier project. Beginning with the triangle, Stornaloco solves the problem of the incommensurable height (which, figuring from the base of 96 braccia already established by the foundations, would be 83.138 . . .) by rounding off the figure to an integral 84 braccia.²⁴ The purpose of this compromise in measurement is immediately evident from the drawing, for it permits the section to be constructed of six equal horizontal divisions of 14 braccia each. The coordination of the triangle and the horizontal divisions provides a logical interrelation between the width of the aisles (16 br.) and the heights of the various portions. Moreover, the geometrical figures provide rational relationships among the several elements in the section itself, and a harmonic connection of the whole to its parts. Stornaloco also suggests a reference to a more abstract harmony by indicating the circle within which the triangle is inscribed, as well as the hexagon inscribed within the circle. This scheme avoids the awkwardly hunched character of the earlier project, and escapes its greatest shortcoming by providing a consistent means of determining the height of the vaults as well as the height of the imposts.²⁵ There is undoubtedly some significance in the fact that Stornaloco has arranged the measurement of the vaults so that the nave is just twice the height of the outer aisle.

Stornaloco's design was accepted and put into practice in the construction of the side-aisle piers and buttresses, but we shall see that it was destined to as short a life as its predecessor. Considering the inconsistent growth of the Cathedral, this reduction in its total height by over $3\frac{1}{2}$ meters was probably a matter of little concern to the builders. A far more important feature of the project was the introduction of a geometrical scheme into the conception.

Meanwhile, Annas de Firimburg had been dismissed, and a frantic search for a successor ensued. A ducal envoy to Cologne failed to discover a "maximus inzignerius" who was willing to accept the position, and an attractive offer to Ulrich von Ensingen, the chief engineer of Ulm Cathedral, was refused.²⁶ Finally, at the end of 1391, Heinrich Parler of Gmünd was appointed

21. The architect Annas (or Giovanni) de Firimburg (Freiburg) is not to be confused with the sculptor Anna de Fernach, who was also active at the Cathedral (see Thieme-Becker, XI, 406, and XIV, 118). This architect was apparently appointed early in 1391, presented his criticisms in writing on March twelfth of that year, and was dismissed in June (*Annali*, I, 45 and 48). His role as the first foreigner to introduce a geometrical scheme for the section may be reconstructed from a statement by a Milanese architect in a conference of 1401. The latter, speaking of a later scheme for the section, says that it respects "il retto ordine del triangolo, che non può essere abbandonato senza errore, come altre volte maestro Enrico, e certo maestro Annex tedesco, primo di lui, predicarono con alta e fedele voce nelle orecchie dei falsi sordi." In a consideration of this conference below, I shall attempt to prove that the "retto ordine del triangolo" specifically refers to the equilateral.

22. *Annali*, I, 55 (13 October, 1391): "Deliberaverunt quod discreto viro Gabrieli Stornaloco de Placentia experto in arte geometriae, pro quo missum fuit parte deputatorum dictae fabricae juxta deliberationem in consilio dictae fabricae factam die 24 septembris p.p. et Mediolanum venit . . . causa discutendi

cum inzigneriis dictae fabricae de dubiis altitudinis et aliorum de quibus dubium erat inter dictos inzignerios . . . dentur . . . dono pro recognitione et recompensatione expensarum per eum factarum veniendo. . . ."

23. A copy of Stornaloco's sketch and the letter which accompanies it is reproduced in Beltrami, *Per la facciata*, III, pp. 12-15, and Frankl, *ART BULLETIN*, 1945, pp. 53-55.

24. The mathematics employed by Stornaloco in calculating the incommensurable heights are interpreted by Erwin Panofsky in a postscript to Frankl's article ("An Explanation of Stornaloco's Formula," *ART BULLETIN*, XXVII, 1945, pp. 61-64).

25. The grid employed in the first project made it impossible to determine the height of the summits of the lesser vaults according to the basic unit of 10 braccia. While the height of the nave vault was probably 90 braccia, and hence consistent with the system, it is significant that Antonio did not record this measurement, and it is possible that the masters were interested in fixing only the heights of the imposts.

26. *Annali*, I, 45 (12 March, 1391), and 51 (15 July, 1391). The mission of March 12 was sent prior to the dismissal of Annas.

to the position.²⁷ After inspecting the Cathedral, he made certain suggestions which were not readily accepted, and a great convocation of specialists was called to discuss his proposals on May 1, 1392. The full record of this conference follows.²⁸

At the gathering of all the engineers named below. . . .²⁹

All [of these] gathered in the building office of the Milanese church in order to remove numerous doubts which are being entertained concerning work at this church, which doubts are separately specified below, and to the doubts are added replies and statements by all these engineers, with the exception of this master Heinrich, who, although these replies are given toward [establishing] an understanding, concurs in no way with these statements.

- [1.] *Dubium*: Whether the portions of the rear as well as the sides and interior—namely, both the crossing and the other, lesser, piers—have sufficient strength?
Responsio: It was considered, replied, and stated upon their soul and conscience, that in aforesaid [portions] the strength, both of the whole and separate [parts] is sufficient to support even more [weight].
- [2.] *D*: Whether this church ought to shed rain (*debeat pluere*) by two roofs or by more, to be constructed from either side up to the transept?³⁰
R: It was considered that this church ought to have, and has to have, three roofs and not two, to afford greater strength and light.
- [3.] *D*: Whether this church, not counting within the measurement the tower which is to be built, ought to rise according to the square or the triangle?
R: It was stated that it should rise up to a triangle or to the triangular figure, and not farther.
- [4.] *D*: How many braccia should the piers be made which support the main nave or the middle nave?
R: It was stated that these piers counting bases and capitals ought to rise to 40 braccia and not farther.
- [5.] *D*: How many braccia should the half-piers be which are to be made in the wall above these large piers up to the vaults or arches to be made above that point, and how many braccia ought the vaults to be made above these?
R: It was considered and stated that the half-piers should be twelve braccia, and the vault of this main nave should rise to the triangle, that is, twenty-four braccia.
- [6.] *D*: What is thought of the design of one double portal of the transept facing the *Compedum*,³¹ and of the entire façade of this transept?
R: When it had been seen and studied, it was stated that it was very beautiful, good and honorable, and that work should proceed according to this [design].³²
- [7.] *D*: Whether or not the chapels of this church ought to be divided or separated one from another, by a wall?
R: It was stated that since these chapels do not need any more strength, that they should remain and be made without any median, or dividing wall.³³
- [8.] *D*: Whether a room or a corridor ought to be made above the second nave, which is between the main nave and the chapels of the church?
R: It was said that this room is on no account to be built, since it occupies funds and adds expense.

27. *Ibid.*, p. 57 (11 December, 1391). The appointment was made for only three months, and was extended on the following March (*ibid.*, p. 66).

28. *Ibid.*, pp. 68ff. (1 May). Appendix 1. This, and subsequent passages which appear in translation are reproduced in the original in the Appendix.

29. A list of fourteen masters is given. After Parler's name is the note, "(who does not concur)."

30. On the basis of the context in *Dubium* 6, "croxeria" is translated as "transept" in this text, although the term occasionally is used elsewhere to mean "vault."

31. The reference is to the Strada del Cómpto, which ran along the north side of the Cathedral. See the map published by Carotti (*A.S.A.*, 1889, p. 116, fig. 2, or the same author's *Il Duomo di Milano e la sua facciata*, Milan, 1888, fig. 2).

32. The northern transept façade was not built as planned here. In Cesariano's groundplan of the Cathedral (*Di Lucio Vitruvio Pollione De Architectura*, Como, 1521, pl. XIII), there is a single portal on each transept arm, which was closed off by the present chapels in 1614 (see Boito, *Il Duomo*, pp. 244-247).

33. The solution of this problem was intentionally delayed until the arrival of a foreign expert. A record of March 19, 1391, which does not appear in the *Annali*, is quoted in Nava, *Memorie*, p. 22. At a conference of masters it is decided, "Quod differatur ad deliberandum supra facto intramezatarum fiendarum in Eccl. ne usque ad eventum inzig. teutonici quem Anes Fernach ire debet ad accipiendum et ducendum, et sic etiam super facto pillonorum ad dictas capellas fiendorum."

[9.] *D*: Whether work on the exterior piers or buttresses is to proceed as it was begun or be improved in any way?

R: It was said that this work was pleasing to them, that there is nothing to be altered, and that, on the contrary, work is to proceed.

[10.] *D*: Whether [work] should proceed on the *guerziis* piers,³⁴ or anything be removed or changed?

R: It was considered that these piers, since they have their proper proportions and parts, are not to be moved, but perfected and refined.

[11.] *D*: How many braccia ought the lesser, or chapel piers, be, and the half-piers which ought to be made in the wall above them, up to the arches which cross over toward the main nave?

R: It was replied and stated that these lesser piers ought to be 28 braccia high, and the half-piers above them constructed up to the arches should and ought to be 12 braccia, counting bases and capitals in these measurements.

A meeting of the following day held to confirm the results of this conference, concludes:³⁵

All the engineers gathered in yesterday's sitting confirm what is written above in all its parts, excepting Simone da Orsenigo, who agrees in general but says that the chapels of the church ought to be divided by a wall in the same manner in which they are joined beneath the ground.

The preamble to the report indicates the customary manner in which major problems are solved. The master engineers summoned to the conference vote on each problem proposed, and the solution is based on the opinion of the majority. Thus Heinrich Parler's special position as a visiting expert does not strengthen his voice in the workshop, and his opinion is equal in weight to that of the least experienced master. To this method of procedure may be attributed some of the council's difficulties in forming a definite and consistent program.

This conference of 1392 is clearly the council's first defense of its *modus operandi*, and the first direct evidence of its opposition to the north. Of the eleven problems considered here, the majority offer two alternative proposals for the future progress of the Cathedral. Since the preamble informs us of Heinrich's unreserved opposition to the solutions agreed upon, we assume that he favored, in each case, those which were abandoned. In fact, a bitter debate may be inferred beneath the calm surface of this report, which, presented in terms of *Dubia* and *Responsiones*, identifies itself with a traditional scholastic disputation. In the subsequent conferences of 1400 and 1401 this method is abandoned, perhaps because it fails to represent the significant differences of opinion.

At the time of this conference the Cathedral was beginning to rise above the level of the foundations, and piers and buttresses had been begun in accordance with Stornaloco's formula. The record of the conference suggests that Parler's criticisms questioned, first, the soundness of the portions already completed, and second, the desirability of continuing to carry out the project determined before his arrival.

In proceeding to the interpretation of this text, it is helpful to dispense with the rather illogical order in which the problems are submitted, and consider the items in order of their importance for the discussion.³⁶

The question submitted in *Dubium* 3: "ad quadratum an ad triangulum?" has in recent times been the occasion for so much elegant geometrizing on Gothic architecture that one hesitates to

34. I have left untranslated the term "pilloni guerziis" for lack of a convincing interpretation. Cf. its appearance in 1401 (*Annali*, I, 223), "... debba . . . riadattari ed abbassare il capitello che esso fece fare sopra uno dei piloni (guerziis)." It is possibly a cognate of the Italian "quercia," in which case it may refer to the wooden models of the piers which are mentioned in note 43.

35. *Ibid.*, p. 69 (2 May). Appendix 1a.

36. The most important decisions made, concerning the height of the church, and of the various supports and vaults,

appear in *Responsiones* 3, 4, 5, and 11. Two problems which should properly be contingent upon these decisions—namely, the adequacy of the piers, and the design of the roofing—are considered beforehand (*Dubia* 1 and 2). Either the text fails to reproduce the original order in which the problems were discussed or, what is more likely, the Milanese are so hard-headed that they believe their piers to be sound, and their roofs correct, regardless of what decisions are made later on concerning the heights of the several portions.

explain it in simple terms. Yet this phrase refers to a problem with which we are already familiar from the drawings of Antonio di Vincenzo and Stornaloco. The importance of the geometrical figure in establishing the design of the section was obvious in Stornaloco's formula. Here it is reaffirmed, and to such an extent that the conferees are initially interested, not in the question, "how high shall the church be?" but "within what figure shall it be designed?" As we have just seen a triangular system was already being used for the Cathedral, and the suggestion that it be altered to a square one is probably Heinrich's.³⁷ What Heinrich means in proposing a square system is simply to make the height of the church equal to its width. By this suggestion, the vault summit, which Stornaloco had brought down to 84 braccia with his triangles, would have shot up to 96 braccia (see *text figure c*).

Parler's suggestion has certain advantages. A section based on a square would be more perfect mathematically, because it would be unnecessary to compromise the figure, as Stornaloco had to do, to achieve commensurable heights. Again, the heights of the various portions of the elevation could be established on the basis of the same 16-braccia unit upon which the groundplan itself was based. To the Italians, however, these advantages were far outweighed by the disadvantages, for the section based on a square would provide a nave so high that the entire system of piers and buttresses would be rendered inadequate (hence the criticism of the supports in *Dubia* 1, 9, and 10). Partly on this basis, the conference spurns Parler's suggestion and reaffirms the triangular section. One would naturally assume that this implies a retention of the program already in effect, but on reading the specifications in *Dubia* 4, 5, and 11, which are substantially those of the present Cathedral (though reduced one-half braccio in execution), it becomes clear that here is a triangular section which is partly Stornaloco's and partly a quite new solution!

What had already been accomplished according to Stornaloco must be preserved, and thus *Responsio* 11 retains the height of the outer piers at 28 braccia. At this height, the equilateral triangle is truncated (see *text figure d* and Fig. 7). The units of 14 braccia which underlie Stornaloco's grid give way to units of 12, as indicated by the measurements determined in *Responsiones* 4 and 5.³⁸ These measurements establish a new geometrical system over the outer piers which proves to consist of figures as familiar as Stornaloco's: adjacent Pythagorean triangles. No mathematician was required at this point, for the short side of a Pythagorean triangle is commensurable with its base, and the height of the church could be calculated readily at 76 braccia. This peculiar alteration upsets entirely the logic of the original scheme. By employing two different geometrical systems, the chief purpose of the triangle—to provide a unified interrelation of the parts and the whole—is ignored.

To understand this capricious shift in mid-air, we must recall that each successive project provides a lower nave (90 br., 86 br., 76 br.), with the exception of Heinrich's, which is higher than any. For some reason, the Milanese became increasingly anxious to give the Cathedral a low, broad section.³⁹ The Lombard Gothic tradition immediately comes to mind as a possible

37. The passage quoted in note 21 informs us that Parler ("maestro Enrico") favored the equilateral triangle. This does not necessarily militate against the suggestion that the square section was also his proposal. I offer that after it had been finally determined to employ the triangle, Parler insisted that it be equilateral, in opposition to the Milanese proposal which we are about to examine.

38. In *Responsio* 4 the piers are lowered from Stornaloco's 42 braccia to 40 braccia. In *Responsio* 5 the engaged columns which rise above the main capitals to the springing of the vaults are lowered from 14 braccia to 12 braccia, and the main vaults lowered from 28 to 24 braccia. The total diminution in height is thus 8 braccia.

39. I believe that the phrase, "and not farther" used in both *Responsiones* 3 and 4 emphasizes merely the wish for a low

section. Frankl, on the other hand (*ART BULLETIN*, 1945, p. 56), suggesting that *Responsio* 3 be paraphrased "up to the Pythagorean triangle or up to the equilateral triangle and not above," proceeds: "If this is right, the words 'et non ultra' mean that one should not enlarge the height of 27.71 . . . to 28 as Stornaloco did, but reduce it to 27½ braccia. This explains the lowering [of the measurements of the present Cathedral] by half a braccio or one foot." This explanation unfortunately does not work. If the outer piers were intended to be 27½ braccia, the main piers (in order to keep within the Pythagorean triangle) would have to be 39½ braccia. *Responsio* 4, however, fixes them at precisely 40. Hence, the reduction of ½ braccio must have been decided upon after this conference of 1392.

motivation (cf. Figs. 1 and 3). The emphasis on breadth which is characteristic of the tradition is in violent contrast with the northern Gothic verticality introduced by Heinrich with his square section. The German is influenced by his former connections with Cologne Cathedral, where we can see to what extent a section *ad quadratum* achieves a climax of the vertical aesthetic in Gothic architecture (Fig. 8).⁴⁰ The evolution of the section, however, cannot be explained on the basis of the aesthetic effect alone, for, after all, two earlier and taller schemes had been temporarily accepted by the council. A more compelling force behind the decision is the buttressing problem, although this is not immediately evident in the report. It will gradually become apparent that the council wishes to keep the nave low enough for the two side-aisles to support it without the aid of additional buttressing, and perhaps even without flying buttresses, as at the Carmine in Pavia. For this reason, the inner aisles retain in all the projects a relatively high elevation in relation to the nave. The extreme caution necessary to carry out such a tradition on an unusually large scale would explain the gradual lowering of the section. The northern builders, who probably regard the flying buttress as their most cherished tool, must have thought the Milanese fools for leaning over backward to avoid its use.

Two of the four proposals we have examined for the section are Milanese, and two German. There is a decided difference. The Milanese are not moved by any conception of rational, causative relations among plan, section, and elevation. The upper portion of the Cathedral is something entirely unrelated to the lower portion or foundations. Under German influence, geometry is employed, but so confusedly that it loses its meaning. On the other hand, the Germans propose systems which interrelate the foundations and the elevation of the Cathedral. Their choice is not arbitrary and capricious, but is limited to two figures, the square and equilateral triangle: the only plausible geometrical figures all sides of which are equal to the established width of the building. Even the geometrical rationalism of the Germans, however, is not the rationalism of Viollet-le-Duc, for two vastly different forms are proposed for the same foundations. The plan must be thought of as structurally independent of the elevation.

Several of the remaining problems considered by the conference may be understood in the light of the decision reached on the various heights. The first of these, concerning the roofing of the western portion of the Cathedral, is discussed in *Dubium* 2. The question of whether to construct three roofs (over the nave, inner aisle, and outer aisle) or two (nave, and two side-aisles combined), depends on the relative heights of the vaults. In proposing two, Heinrich must again have had Cologne Cathedral in mind (Fig. 8), and must certainly have intended his outer aisles to be considerably lower than the nave, and of approximately equal height, as in our reconstruction of the section *ad quadratum* (figure c). The combining of the outer aisles under one roof which is quite plausible in this project, becomes impossible when, in a later discussion, the vaults of the middle aisles are fixed at 12 braccia over those of the outer aisles (figure d). Three roofs became necessary, "to afford greater *strength* and *light*," by which the masters mean that (1) the middle aisle must be relatively high and the nave relatively low for buttressing purposes (hence, the "strength"), and (2) this being determined, a single roof could not cover both aisles without also blocking the windows of the nave (hence, the "light").

The answer given to *Dubium* 8 also is determined by the establishment of a high middle aisle. The "room or corridor" proposed by Heinrich is probably a kind of triforium gallery opening onto the nave above the main arcade, such as may be found throughout mediaeval architecture

40. My hypothesis that Cologne Cathedral is constructed *ad quadratum* is based on Dehio's section reproduced in Figure 8, where the height of the nave keystone is equal to the breadth of the building measured from the inner surface of the walls. Paradoxically, Dehio himself lists Cologne as an example of construction *ad triangulum* (*Die kirchliche Baukunst des*

Abendlandes, Stuttgart, 1901, II, 567, and *Ein Proportionsgesetz der antiken Baukunst*, Strasbourg, 1895, pp. 21, 23). He claims that the height of the vault is established by superimposing small equilateral triangles. As in all questions of this kind, the answer must await accurately measured drawings.

and, of course, at Cologne. If the section were designed *ad quadratum*, such a gallery would be desirable as a means of lightening the wall between the main arcade and the clerestory. The main arcade, however, has just been planned to reach to the very springing of the nave vaults, and there is simply no room for such a "corridor." The triforium gallery does not appear in Lombard Gothic churches, and the master's reply indicates that they consider it a foolish luxury.

The numerous references to "chapels" in the text, and the particular concern for their design shown in *Dubium* 7, is puzzling in view of the fact that they cannot be identified on the plan. However, the references made in *Dubia* 8 and 11 make it clear that the "chapels" are the bays of the outer aisles, and if they are not identifiable as such, it is because of the decision reached in *Responsio* 7, "that they should be made without any dividing wall." Why the term "chapels" is used, once it is determined to build an uninterrupted aisle, is explained in the postscript to the report. Simone da Orsenigo, one of those responsible for the first plans of the Cathedral, refers to the "manner in which they [the chapels] are joined beneath the ground," which indicates that the original plan and foundations provided for an outer chapel-row such as is found in the standard plan of Lombard Gothic churches (Fig. 2). This offers convincing evidence for our contention that the first project for the Cathedral was in the Lombard tradition, and that its great breadth does not reflect the influence of northern five-aisle plans. Northern influence might appear to effect the tardy decision to change the chapel-rows to aisles, but the report suggests a different cause. *Responsio* 7 indicates that the dividing walls are considered useful only if additional "strength" is required. This can only mean that such walls are, in reality, interior buttresses. They are now felt to be unnecessary because the vaults of the nave have been lowered to a point at which their thrust can be absorbed by the two outer aisles without such assistance. The masters are convinced of the stability of the new project, and are anxious to carry it out with a minimum of buttressing of any kind, as is again indicated by *Responsio* 9, where the small wall-buttresses of the earliest plan are retained. Heinrich, on the other hand, must feel that the whole support system is dangerous. He is probably constrained to endorse the provincial chapel divisions of *Dubium* 7, as the only means of adequate buttressing which the council would be likely to accept, although he would normally favor an open aisle.⁴¹

In summary, the various questions posed in the conference, appearing at first sight to be entirely discrete considerations, prove on analysis to be intimately related. The solutions of the conference represent a single-minded aim to establish a low and broad profile with a view toward minimizing the buttressing. This aim has grown with the Cathedral, which is now both lower and less buttressed than originally planned. At all points these solutions conflict with the aesthetic and practical concepts of the northern master, to whom they must appear an incomprehensible folly. Heinrich sees in the foundations a bad beginning which might somehow be made into a Cologne Cathedral, but his ideas are so basically opposed to those of the Milanese that even small compromises are impossible. A logical structural system proven by long practice is thus spurned in favor of one which, while it has vague parallels in small, provincial, brick churches,

41. The decision concerning the chapel divisions was perhaps the most controversial one of the conference. As time went on, several of the local masters joined the northern experts in the conviction that these divisions were necessary to the stability of the Cathedral. Nine years later the controversy still was a major issue, and the Duke ordered Bertolino da Novara, and his court architect Bernardo da Venezia (who had subscribed to the original decision to abandon the divisions), to give their opinion on the matter. Their report, dated May 8, 1400 (Appendix v), includes the suggestion: "First because the buttresses of the body of the church do not have all the mass that they need, considering the breadth and height of said church, the first nave should be reduced to the form of chapels with the divisions between one chapel and

another, with several perforations through which one could see the Host from either side of the church. Such a construction would succeed in giving the greatest strength to the other three naves, and through these flying buttresses, as it were, its base would be stronger, and the body of the church would look more beautiful, and more in proportion, and would follow the grandeur of the transept (? *cruxe*)." The advice of the two experts was of course ignored, as was virtually all outside opinion.

It is worth noting that the chapel system had lost its liturgical function to such an extent that the dividing walls were considered a hindrance to the congregation which must be alleviated by "several perforations."

is purely experimental on this scale. Should such an experiment succeed, it would be proof either of the inventive and technical skill of men seeking to find new forms, or the sheer good luck of innocents who will try anything rather than adopt an established foreign style. From our knowledge of the wayward progress of the Cathedral thus far, the latter alternative appears the more likely.

The immediate effect of the conference of May 1392 was the dismissal of Heinrich Parler under a shower of invective which he can hardly have deserved.⁴² For two years the Milanese proceeded without the hindrance of northern aid, facing the walls and continuing the piers. Their indecision was again made evident in 1393, when it was questioned whether the design of the one pier capital which had been completed should be employed for the remainder.⁴³ When Ulrich von Ensingen was finally persuaded to come from Ulm to Milan in October 1394, he refused to execute the projected capitals or the apse windows, and left six months later without having reached any understanding with the council.⁴⁴

During the following years, the Milanese were not disturbed by the necessity for imperative decisions, for they simply postponed the final solution of the vaulting problem until the completion of the piers forced it upon them. The appointment of three French engineers in April 1399, indicates that the accumulated weight of construction problems obliged the council to seek again for assistance from the north.⁴⁵ By December the leader of the deputation and one assistant had left the field to their persistent and belligerent associate, Jean Mignot, who lost no time in assuring the Duke that the Cathedral was destined to fall if certain alterations were not immediately undertaken.⁴⁶ At a hearing of January 11, 1400, the Frenchman presented his extensive criticisms to the local architects for discussion.

Mignot, like the experts who preceded him, applies standards of construction and theory which are firmly based in northern tradition, and any deviation from his norm he interprets as an error. The fifty-four criticisms which he levels against the council make no concessions to Lombard originality. Although they are partly justified, the aggressive and repetitious manner in which they are presented enrages the other conferees, who refuse to reply to more than half of the items.⁴⁷ Most of the criticisms concern details such as the form of mouldings and the laying of stone, and must be passed over here. The two exchanges of opinion which we shall examine are perhaps the only ones in which questions of theory play a major role.⁴⁸ The conference opens with the most weighty problem, which brings us back again to Heinrich Parler's criticism of the system of piers and buttresses. Mignot says:⁴⁹

42. *Annali*, I, 71 (7 July, 1392). The Cathedral deputies say that Heinrich "... male servierit ipsi fabricae, ymo dedit magnum damnum et detrimentum ipsi fabricae pro suis malegestis. . . ."

43. *Ibid.*, p. 105 (14 December, 1393): "Quod si videatur alios capiteles posse meliorari referant, et fieri faciant de formis hujusmodi capitelorum fiendorum in futurum de ligno aut gesso, ut determinari possit circa alios capiteles fiendos pro utiliori fabricae."

44. For Ulrich's arrival see *ibid.*, p. 120 (15 November, 1394), and departure, p. 134 (28 March, 1394). From the latter: "dixit non velle facere ipsam fenestram secundum mensuras ordinatas, quia volebat mutare altitudinem et modum ipsius fenestrae; et ulterius si volebat facere de capitelis pilonorum, similiter dixit quod non volebat facere de capitelis pilonorum in illa mensura qua finitus est primus capitelus. . . ."

45. *Ibid.*, I, 194 (13 April, 1399).

46. *Ibid.*, I, 199 (14 December, 1399): "Avendo l'ingegnere Giovanni Mignoto riferito al Duca che la fabbrica corre pericolo di ruina, gli ordinarono di farne relazione scritta,

ed intervenire in seduta per le necessarie deliberazioni."

47. Twenty-five criticisms are answered by the masters. The postscript to the report explains their silence in the second half of the conference: "No response is given to all these statements by above-mentioned Jean Mignot, since they contain neither substance nor weight, and especially since, if they [the masters] should reply to aforesaid statements, and others which he might give in writing in the future, the negotiations would never end, but the work on aforesaid church would be held back to the great shame and scandal of men, not only in the city, but in the whole realm of the illustrious lord, our Lord, and consequently would never be finished" (*Ibid.*, p. 208).

48. A third criticism of which the content may be significant from a theoretical standpoint I have been unable to interpret for lack of evidence on the precise state of the Cathedral in 1400. Because of its geometrical allusions it has been included in Appendix 11a. The square and circle referred to may describe either the section of the pier or the arrangement of the piers in the plan.

49. *Annali*, I, 202 (11 January, 1400), Item 1. Appendix 11.

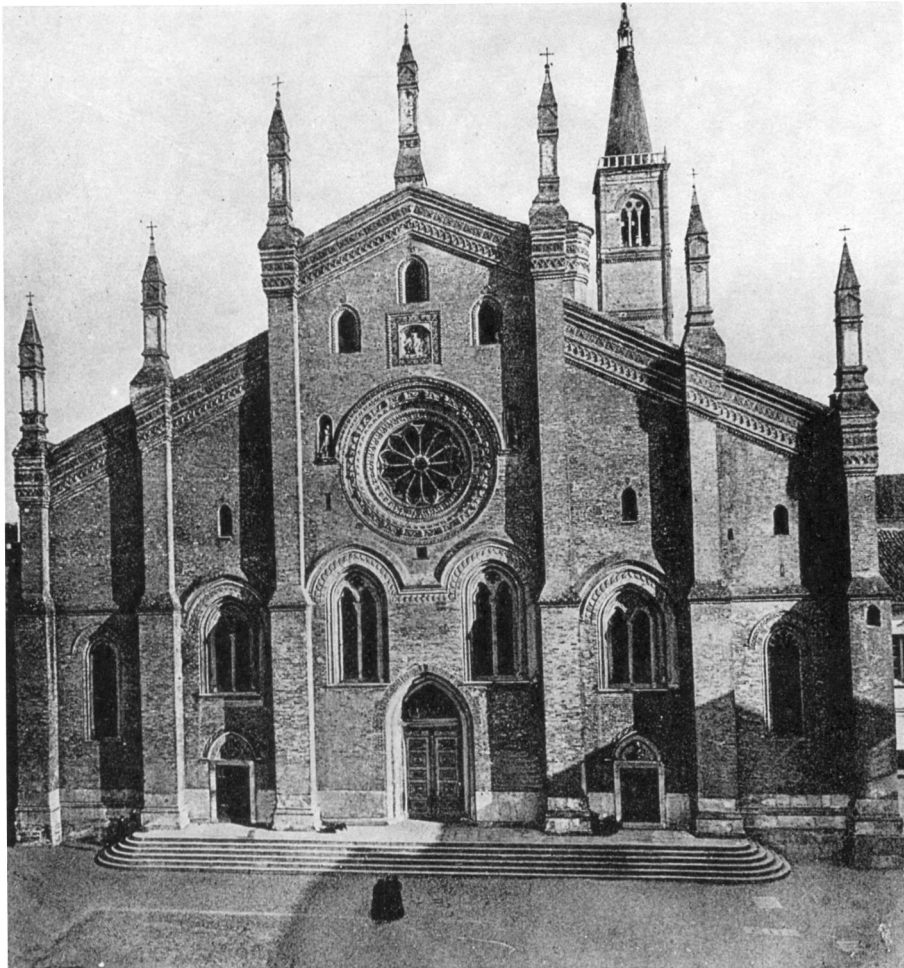


FIG. 1. Pavia, Santa Maria del Carmine

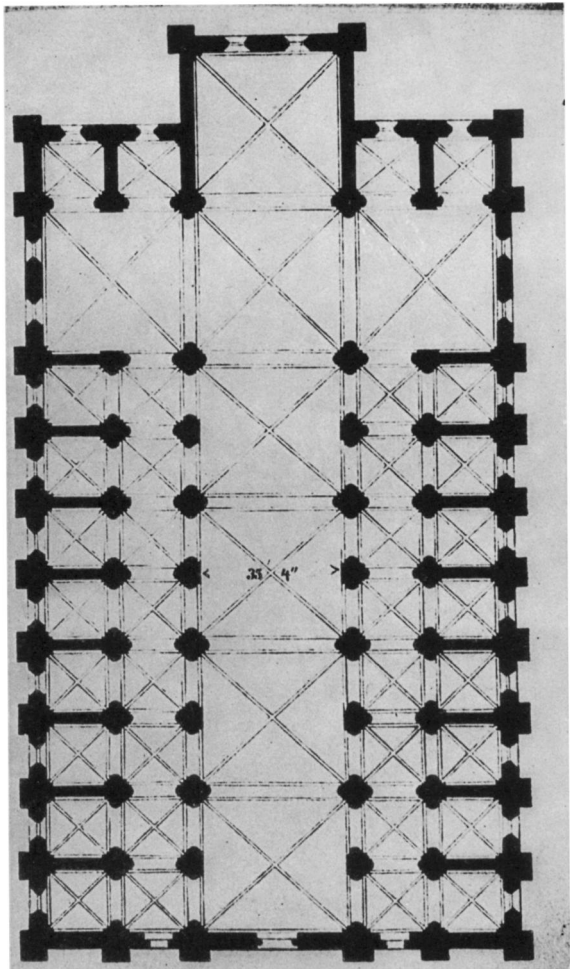


FIG. 2. Pavia, Santa Maria del Carmine. Plan

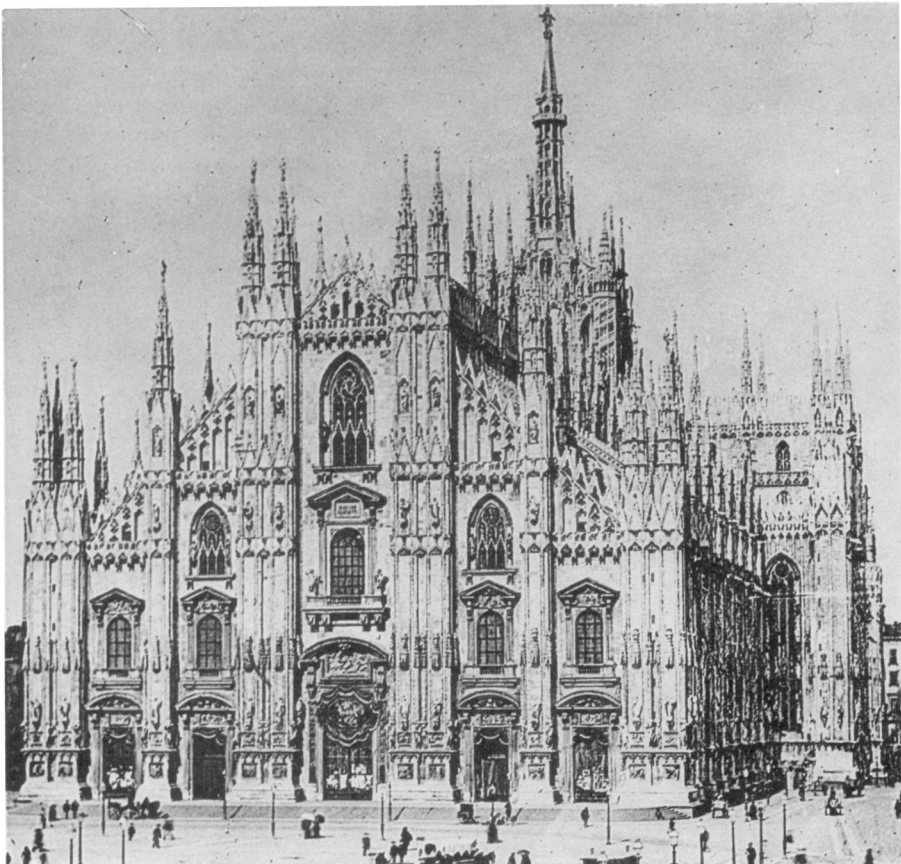


FIG. 3. Milan, Cathedral

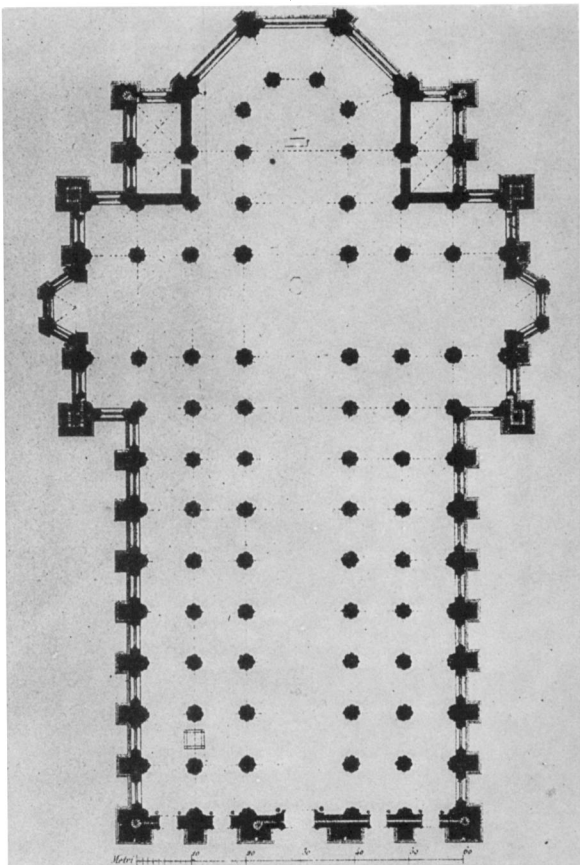


FIG. 4. Milan, Cathedral. Plan

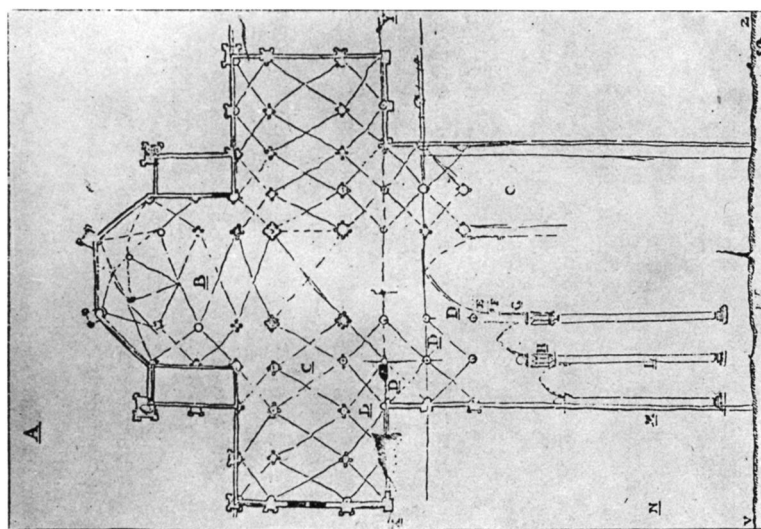


FIG. 5. Milan, Cathedral. Plan and nave section in 1390, from sketch by Antonio di Vincenzo (after tracings by Luca Beltrami)

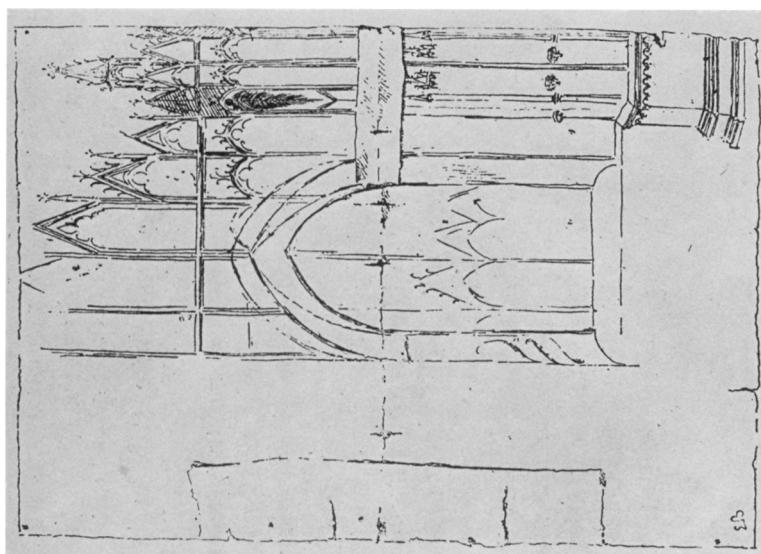


FIG. 6. Milan, Cathedral. Exterior elevation of a sacristy, verso of Fig. 5.

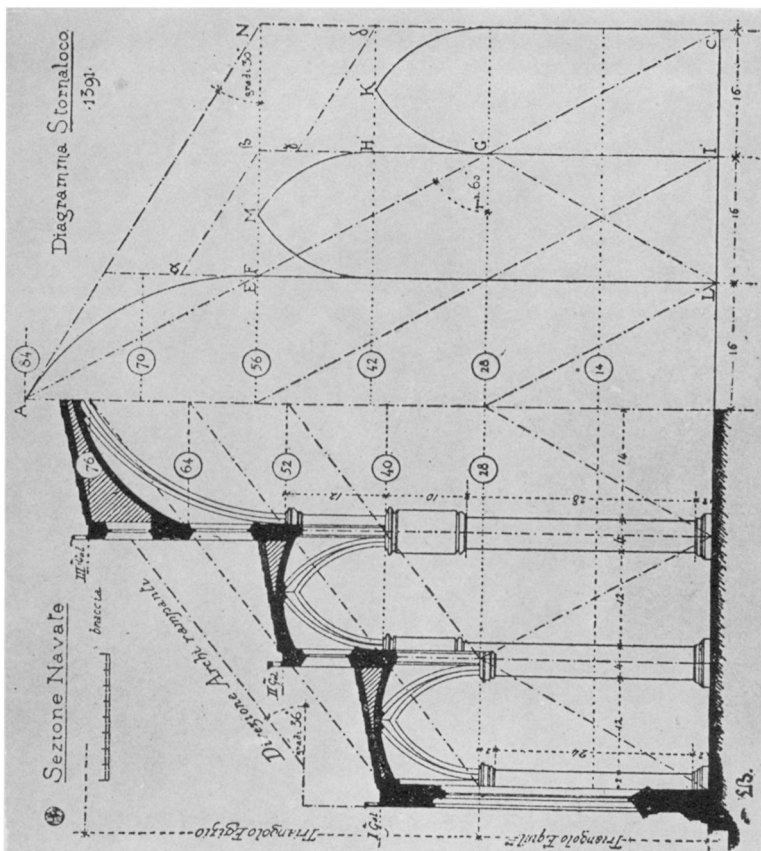


FIG. 7. Milan, Cathedral. Composite drawing of projects illustrated in text figures *b* and *d* (after Luca Beltrami)

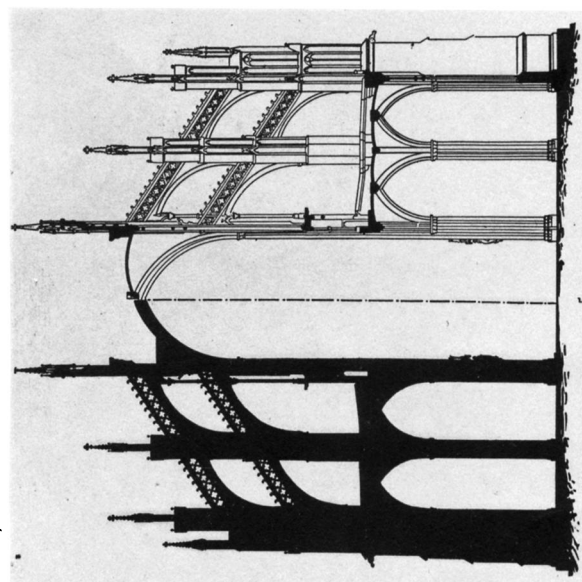


FIG. 8. Cologne, Cathedral. Nave section (after Dehio)

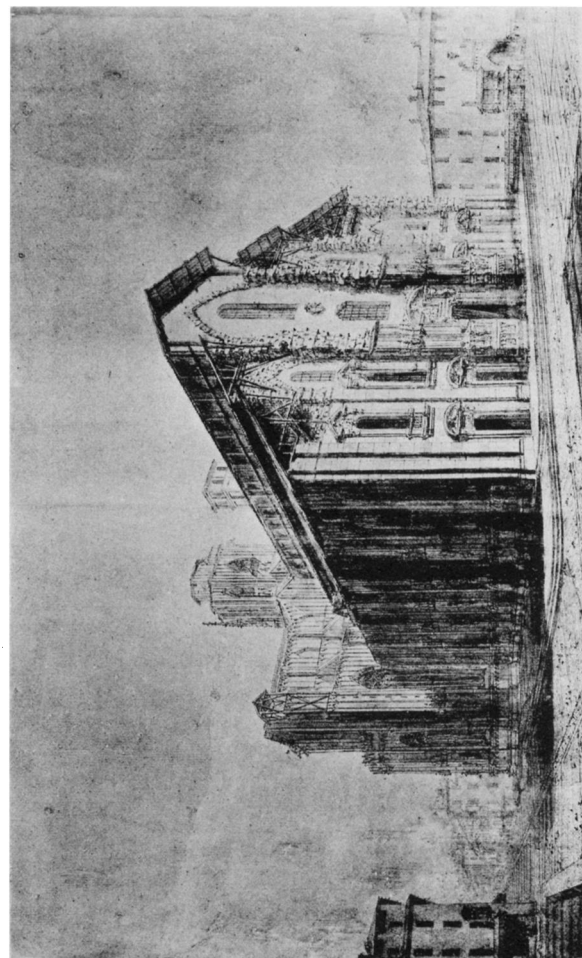


FIG. 9. Milan, Cathedral. From drawing of ca. 1750

First, the piers [or buttresses] which have to support and sustain the rear portions of said church between the large windows are so weak that it is necessary to make two other reinforcing piers next to them, nor will this part of the church be as strong as it should be until these two are made.

The criticism is leveled particularly at the apse of the Cathedral. Here the large windows, the small wall-buttresses and the absence of chapels minimize the capacity of the outer wall to sustain the vaults and projected tower.

The masters' retort to this criticism conscientiously traces the construction of the piers from foundation to capital. They begin by asserting that both the counsel of experts and their own formal oath attests to the security of the foundations, which are sunk 14 braccia into the ground.⁵⁰ They explain that the lower levels of the foundation are composed of large blocks of stone jointed or doweled together, and that $3\frac{1}{2}$ to 4 braccia are allowed in the upper portions for leveling off, while the marble dado commences in the upper half-braccio of the foundation. The piers themselves are provided with a core of finished building-stone, "and for greater strength they are doweled everywhere with spikes of leaded iron." In answer to the specific criticism of Mignot, they explain that they intend to reinforce the piers by joining one to another with large iron binding-rods to be placed above the capitals.⁵¹ Finally, the council comes to the point which is designed to clinch the argument:

And above said capitals, they determined, as had been [previously] determined, to have pointed arches made according to the type suggested by many other good and expert engineers, who say concerning this that pointed arches do not exert a thrust on the buttresses, and for aforesaid reasons they conclude that all the buttresses are strong and adequate to carry an even greater [weight], wherefore it is not required to make [additional] buttresses in any part of the church.

Suddenly, amid a sober and painstaking analysis of technique, there is injected an explosive mechanical principle, "pointed arches do not exert a thrust on the buttresses." In a single sentence the Milanese have cast off what we consider to be the major structural problem in Gothic architecture. It would indeed be a shock to the modern historian if this view were found to be in general currency among Gothic builders, and it is with some relief that we discover in a later discussion that it is as surprising to Mignot as it is to us. The council, which to this point has appeared to be merely retarded and stubborn, begins, in its antagonism to Mignot, to fabricate strange theories to suit its ends. It becomes apparent that the fervor of its defense is a sign, not of superior confidence, but exceptional ignorance.⁵²

50. The same passage quoted in Nava, *Memorie*, p. 86, gives the depth of the foundations as 9 braccia, which seems more likely than 14. By way of comparison, the records of Florence Cathedral of June 1357, provide: "che il fondamento delle cholonne dallo spazio in giù si faccia br. vij per ognie verso" (Cesare Guasti, *Santa Maria del Fiori; la costruzione della chiesa e del campanile secondo i documenti*, Florence, 1887, p. 94). The Florentine braccio is only about one centimeter less than the Milanese (see *Enciclopedia italiana*, VII, 649).

51. The use of binding-rods between the capitals to reinforce the arches was common practice in Italy, and probably less frowned upon than in the north. See again the records of Florence Cathedral for August 3, 1366: "... chonsigliano che al presente si facciano due stanghe di ferro grandi di buono ferro e bene salde, e mettansi negli archi de le volte grandi, cioè una in ciascuno archo . . ." (Guasti, *op. cit.*, p. 173).

52. Mignot evidently feels that it is hopeless to attempt to make his point against such opposition. In a second hearing which he is granted a few days later, and which we shall shortly consider, he asks that experts from any northern country be called in to testify whether or not his criticisms are justified. Consequently, a month later, on February 21, 1400, a deputation of three "inzignerii francischi" en route to Rome is asked to pass judgment on the apse supports. The report

reads: "First it was asked on this question by the above-mentioned lords if it seemed to them that this church were sufficiently founded to sustain and carry the weight belonging to said church.

"We the aforesaid engineers and masons say that we have seen and reviewed all of said church, and especially we have seen the foundations of two piers exposed, which two piers should sustain and abut the apse of said church, and are inadequately and poorly founded. And one of these is more than a foot at fault inside the work, and of poor material. All the piers of said church both inside and outside are to be reviewed down to the lowest base and all those which were badly founded as are the aforementioned, are to be refounded of large blocks of well-laid stone, and their bedding should be well leveled and planed and joined and buttressed by dovetailing into the other foundations well inside, and built in with a mortar bath. These foundations should be made two braccia or more beyond the plumb line of the bases of the piers, coming to one braccio at the surface by a setback.

"Furthermore, it was asked and the question was put if the aforementioned two piers outside the apse of said church are strong enough to sustain and buttress against all its weight.

"We state that if one founded two piers for carrying two flying buttresses, that the church would be made stronger, but

A second passage concerns a problem in design which is quite different from those we have examined previously, for it is purely aesthetic in nature. One of the unique features of Milan Cathedral is the design of the huge capitals on the piers of the nave and side-aisle. Large enough to contain colossal statues of saints in niches, the capitals appear in Antonio's sketch of 1390 (Fig. 5), and were probably conceived before the advent of northern experts. Mignot's reaction to this invention is what one would expect of a Parisian—he finds it monstrous:⁵³

Moreover, that the pier capitals placed in the work above these piers are not placed according to their proper proportion, since the feet of these piers are two braccia regardless of the height, and the capitals are x braccia regardless of the height, and these capitals ought to be of the same height as the feet of these piers.

They say and reply that, according to that reasoning, if the feet or bases of the piers are two braccia, the capitals ought to be one braccio. [However,] they say that the base of the pier is called a foot [after?] the foot of a man, and it is said of the capital [that it is] the head of the pier, so by "capital" is meant the head (*caput*) of a man. Further, the foot is a fourth part of a man's head, and by this natural law they (the capitals) should be viii braccia, and if they were made x braccia, it is on account of the ornamentation of the piers, for the placing of figures.

The Frenchman's reaction is typically academic. He says, in effect, that a proper Gothic capital is the same height as its base, and no deviation is permissible. Here the Milanese believe that they have the best of their adversary, for they point out that if the capitals were to be truly proper in Mignot's sense, they should be half the size of the base.⁵⁴ It is not their intention, however, to observe propriety. Their attitude is epitomized in a statement made in a later controversy with Mignot, "la nostra chiesa non richiede cose vecchie ma nuove,"⁵⁵ and their answer is not only non-academic, but amazingly non-Gothic. The anthropomorphic, almost Vitruvian, terms of the defense are decidedly *cose nuove* to mediaeval aesthetics, and one hesitates to suggest what their source might be. While a certain classical attitude is suggested, the result is not classical proportion. The width of the pier is of no consequence, and while a plausible relationship (1:4) between "foot" and "head" is established, the "body" is not taken into consideration. Consequently, the capital measures one-fifth of the total height of only 40 braccia—an anthropomorphism which takes a sorry view of the human form.⁵⁶ The argument, it appears, is something of a fraud, and must have been concocted after the fact. It is our opinion that the actual motivation for designing capitals 8 braccia high is a geometrical reasoning which is entirely consistent with the theory we have so far considered. If the pier is 40 braccia and the capitals 8, then the shaft is 32 braccia, which is precisely the width of the nave itself. Interpreting these measurements geometrically, the height of the shaft is determined *ad quadratum*, a method which is much more likely than the one stated in the argument.⁵⁷ Finally, it is typical of the Milanese that, while they adduce a law to explain their design, they do not consider it binding. They feel that if the proportions prejudice the decorative scheme,

to avoid impediment, we state that it should be refounded of one weight of large blocks of good stone, and mortared (? *goger*) and joined (? *gont*), that is, well squared and set in a bath of mortar of four braccia abutting along the whole length up to the level of the earth. And said stones should be buttressed by dovetailing below the other foundation, and from ground level up, by lengthening or widening said two piers by two braccia all the way up. And the new stones should be doweled with the old ones, and in this fashion we think they can carry their weight.

"Furthermore, it was asked and the question was put if all the other piers of said church seemed to us to be good.

"We state that if they were to be made now they could be made better . . ." (*Annali*, I, 211; Appendix IV).

Thus the judgment of the deputation bears out Mignot's opinion, suggesting not only that the wall-piers be reinforced, but that they carry flying buttresses. The criticism of the foundations suggests that the foreigners believe the Milanese to

be quite as deficient in practice as they are in theory.

53. *Annali*, I, 203f., Item 9. Appendix 11b. The reader is advised to refer to the original, as the phrasing of the reply eludes adequate translation.

54. In a sense, the Milanese are more up-to-date in their argument than Mignot, for the capital-base ratio averages about 1:1 in early Gothic architecture, while later the capital tends to shrink and the base to grow, although not according to fixed ratios.

55. *Annali*, I, 224 (15 May, 1401).

56. In Vitruvius, for example, the proportion of head to body is 1:8. See *De Architectura*, III, c.1,2.

57. Beltrami (*Per la facciata*, III, 18) draws essentially the same conclusion from the piers as executed. He demonstrates that a base of 2 braccia, and a capital of 10 braccia leave between them a shaft of 28 braccia, which is equal to the width of the nave measuring from the exterior of the columns rather than the center.

they may justifiably be altered, and thus the capitals are enlarged by two braccia to provide ample room for the statues. The compromising of these measurements, like the compromising of the principle of triangulation, reveals an indifference to a theory which the unorthodox and illogical arguments prove to be largely beyond the comprehension of the Milanese masters.

Mignot's first conference bore no fruit, and a fortnight after the hearing in which the fifty-four criticisms were considered, a second meeting was called to reconsider his most serious allegations. The report on the proceedings, which we present in full, begins:⁵⁸

Master Jean Mignot has stated to the council here present that he has given in writing to the said council a note computing to date all the reasons and every motive which lead him to say that aforesaid work lacks strength, and he does not wish to give other reasons.

Final statements given by aforesaid Master Jean on the 25th day of January.

Master Jean Mignot points out to you excellent lords of the workshop council of the Milanese church with respect and pure truth, that as he has demonstrated in writing elsewhere and among other matters, the defects of said church, he reiterates and affirms that all the buttresses around this church are neither strong nor able to sustain the weight which rests upon them, since they ought in every case to be three times the thickness of one pier in the interior of the church.

The Masters reply:

Concerning the first statement, they say that all the buttresses of said church are strong and capable of sustaining their weight and many times more, for many reasons, since one braccio of our marble and *saritium*,⁵⁹ whatever its width, is as strong as two braccia of French stone or of the French church which he gives to the aforesaid masters as an example. Therefore they say that if aforesaid buttresses are one-and-a-half times [the size]—and they are—of the piers in the interior of the church, that they are strong and correctly conceived, and if they were larger they would darken said church because of their projection, as at the church in Paris, which has buttresses of Master Jean's type, and since they can be an obstruction [there are] other reasons.

This chauvinistic retort provides a highly entertaining insight into the council's method of reasoning, but the argument reveals more than mere prejudices. First of all, Mignot categorically states that there should be a 1:3 ratio of thickness between the piers and buttresses. It is possible that this ratio represents his final estimate of the peculiar requirements of Milan Cathedral, but it is more likely that he is applying a simple rule-of-thumb which is common practice among northern architects. None of Mignot's statements, either here or in the previous conference, gives any indication that he has even a crude means of arriving at a more precise estimate of the amount of buttressing required. In a sense, the terms of the ratio create a simple relationship between the mass of one member and another in the same way that the section *ad triangulum* relates their profiles. It is noteworthy that, while the Milanese propose a drastically different solution, they place particular emphasis on a similarly simple relationship of 1:1½.

It is particularly interesting that the masters' defense is based solely on the argument that the size of a buttress should be determined in inverse proportion to the *strength* of its component materials. The strength of masonry is of course a factor in computing support, but one may well be suspicious of the Italians' claim of great superiority in this respect. While they may be justified in proposing buttresses smaller than those of the "church in Paris," one feels that the real justification lies less in the greater strength of their materials than in the lesser thrust on their exterior walls. Had they been aware of thrust, the weight and mass of the buttresses would probably have concerned them more than the strength, but we know from their earlier estimate of the pointed arch that they were not conscious of the problem.

Of the two solutions offered, one is based on traditional northern practice, the other on a mixture

58. *Annali*, 1, 209f. (25 January, 1400). Appendix III.

59. A local building-stone, employed in the foundations and under the marble facing.

of Lombard tradition and sheer ignorance, but neither on an accurate estimate of the requirements. It might be objected that this judgment is harsh in relation to Mignot, for his solution is founded on reasonable premises; but the evidence indicates that—in defiance of reasonability—the council's solution triumphs, and the present-day buttresses are indeed half the size demanded by the Frenchman! The empirical solutions of both parties to the dispute are, from the modern point of view, unscientific. They are not, however, irrational, for they establish a relation between members which, though irrelevant to us, is meaningful to their authors.

The remainder of the discussion follows:

Moreover, he says that four towers were begun to support the crossing-tower of said church, and there are no piers nor any foundation capable of sustaining said towers, and if the church were to be made with said towers in this position it would infallibly fall. Concerning the claims, however, which were made by certain ignorant people, surely through passion, that pointed vaults are stronger and exert less thrust than round, and moreover concerning other matters, proposals were made in a fashion more willful than sound; and what is worse, it was objected that the science of geometry should not have a place in these matters, since science is one thing and art another. Said master Jean says that art without science is nothing (*ars sine scientia nihil est*), and that whether the vaults are pointed or round, they are worthless unless they have a good foundation, and nevertheless, no matter how pointed they are, they have a very great thrust and weight.

Whereupon they [the Masters] say that the towers which they wanted to make are for many reasons and causes [desirable]. Namely, in the first place, to integrate aforesaid church and transept so that they correspond to a rectangle according to the demands of geometry,⁶⁰ but beyond this, for the strength and beauty of the crossing-tower. To be sure, as if as a model for this, the Lord God is seated in Paradise in the center of the throne, and around the throne are the four Evangelists according to the Apocalypse, and these are the reasons why they were begun. And although two piers of each sacristy are not founded, but begin at ground level, the church is truly strong nevertheless for these reasons, that there are projections upon which the said piers stand, and the said projections are of large stones and joined with iron dowels as was said above with other statements, and that the weight on these three (*sic*) towers falls evenly on their square, and they will be built properly and strong, and what is vertical cannot fall; therefore they say that they are strong in themselves, and for that reason will give strength to the crossing-tower, which is enclosed in the center of those towers. Therefore said church is truly strong.

Mignot makes one specific criticism: that the four towers to be placed at the corners of the crossing-tower cannot be supported. In defense of its design, the council makes four points, of which the first two purport to justify the theory underlying the towers, and the remaining two, the technique of construction. The first establishes a certain relation between the towers and the crossing, "according to the demands of geometry." Again, we have the suggestion of an interrelation of part to part, in this case an element in the plan to an exterior elevation. How the four subsidiary towers effect this integration is unclear. It may be that they are intended as a symbolic emphasis to the geometrical character of the plan, but it is more likely that they were conceived for non-theoretical reasons, and that the geometrical apology is concocted on the spur of the moment in the face of Mignot's accusations. Geometry does not explain the towers, it excuses them. The second statement, which compares the design to an Apocalyptic vision, is a delightful addition to the study of the iconography of architecture. It is undoubtedly more congenial to the Milanese than the struggle with geometry, but if calculated to convince Mignot, it must fail completely, for it evidences an attitude very different from the abstract mathematical theory of the northerners. Like many of the preceding theoretical demonstrations, it rationalizes a design conceived without benefit of theory.

In defense of the construction, the first point is purely technical, claiming that the absence of foundations beneath the sacristy piers is compensated for by secure doweling. This judgment is

60. Aside from the reappearance of the elusive term "croxeria," it is difficult to determine with any precision what the masters have in mind in this sentence, which reads, "pro rectificando praedictam ecclesiam et croxeriam quod respondent ad quadrangulum etc."

questioned later, as we have seen in the expertise of February 1400, quoted in note 52. The final argument is as irrational as that which concerns pointed arches. It claims that the security of the project is assured, first because the weight of the towers is to be evenly distributed on their square base, and second because "*what is vertical cannot fall.*" In other words, neither the size and weight of the towers, nor the number and mass of their supports (to say nothing of the stresses created) are significant, if their construction is rectilinear. Fortunately, the design under discussion was never carried out.

The meeting closes with the following exchange:

Moreover he [Mignot] recognizes that their premises are willfully conceived, nor do those who disagree wish to give in to the right and the betterment of said church and workshop, but want to win their case either for their own profit or from fear, or else from obstinacy, since they would like to continue in spite of defects. For this reason said master Jean requests that four or six or twelve of the better engineers who are expert in these matters might be brought together, either from Germany, England, or France, otherwise said work will certainly fall, which would be a great loss in every way. Further, to make the truth clear and to conserve his honor, he wishes to be allowed an audience with the illustrious lord the Lord, to explain to him in general the aforesaid things and other matters. Moreover, he indicates that it would be for the good of the church to work elsewhere in said church than over defective places, at least until such time as provisions and decisions might be clearly made concerning these defects.

Whereupon they [the masters] say and reply in the same statement, that where it says that the science of geometry should not have a place in these [matters], the above-mentioned say: if he [Mignot] invokes, as it were, the rules of geometry, Aristotle says that the movement of man in space which we call locomotion is either straight or circular or a mixture of the two. Likewise the same [writer] says elsewhere that every body is perfected in three [ways], and the movement of this very church rises *ad triangulum* as has been determined by other engineers. So they say that all [the measurements] are in a straight line, or an arch,⁶¹ therefore it is concluded that what has been done, has been done according to geometry and to practice, and even he [Mignot] has said that science without art is nothing; concerning art, however, replies have been made already in other statements.

Considering the conference as a whole, it becomes abundantly clear that the attack with which Mignot opens the meeting is justified. We see that he ascribes the council's position on the pointed arch to "ignorance" and "passion." His main objection, however, is to the council's contention that "the science of geometry should not have a place in these matters since science is one thing and art another." This exposes the crucial difference between the two schools of thought which we have repeatedly emphasized. For "science" we may read "theory"—the higher learning in architecture. Mignot goes on to imply that it is through ignorance of this "science" that the council is unaware of the "very great thrust and weight" of a pointed arch, or vault. Without this science, he says, art is nothing. He is not, of course, talking of "Art" in the modern sense, but in the sense of craft; in this case the craft of the mason. His statement may be paraphrased to read, "technical proficiency in building is worthless if the higher geometrical principles are not employed." There is no question that the implied criticism is warranted. The axiom "what is vertical cannot fall," which we have just considered, is an excellent example of thinking in terms of "art without science," for it suggests that the soundness of the scheme depends solely on good technique. In retrospect, a large part of the entire Milanese defense champions "art," as we are reminded by the closing statement of the meeting. In defending the apse supports, they tirelessly describe the foundations; in defending the buttresses they affirm the superiority of their masonry, and so forth. The pride which they display in their technique is understandable, since the Lombards are famed for their masonry from the early Middle Ages through the Renaissance.

61. "per rectam lineam aut per *sextum*." Cf. the Italian *sesto acuto*.

The partiality which the Milanese manifest for "art" in contrast to "science" is explained by a familiarity with the former (which is probably greater than Mignot's), and an almost complete ignorance of the latter. We cannot ignore, however, their occasional flights into the realms of geometry. In such cases, one has the impression that, while they are quite discomforted by a science in which they have so little proficiency, they are constrained to pay it lip-service. The history of the triangular section, for example, proves that foreign influences were the cause of this constraint, for the section projected before the advent of northerners was designed without the aid of geometry. Similarly, in the closing argument of the present conference, the Milanese are shamed by Mignot into a scientific discourse which it is far beyond their capacity to carry off. In attempting to hide their deficiencies, the masters have taken cover behind irrelevant quotations from Aristotle, intending the mere reference to lend authority to their claims. The first of their "geometrical" proofs is borrowed from a passage in the *Physics* which concerns infinite motion.⁶² Chosen for the reason that it refers to straight and circular lines, it is perverted into a rationalization of the straight lines and arches of the Cathedral. It may readily be seen that this argument is invalid; not only because it implicitly claims that the Cathedral is correctly designed simply because it has piers and arches, but also because it applies a law of locomotion to a problem which is specifically claimed to be geometrical. The second proof is more to the point, for in defending the triangular section, the council is actually demonstrating an example of its deference to geometry. The attempt to adduce the support of Aristotle, however, is again abortive. The statement, "every body is perfected in three ways" is adapted from certain passages of Aristotle which refer, not to extension, but to dimension (the "three ways" are height, breadth, and depth), and its application to the triangle (which has three sides but only two dimensions), completely perverts the original meaning.⁶³ The entire passage shows that the question of "Science" has caught the council unawares. The masters are in such a hurry to appear scientific that they choose the wrong passages, if not the wrong authority, for a *post facto* rationalization of their work. Having grossly misused Aristotle, they apply the same treatment to Mignot, and, reversing his statement to suit their own philosophy, they conclude with the misquotation, "science without art is nothing."

As might be expected, the meeting ends in the same spirit of antagonism in which it begins. The discussion bears fruit in one respect, however, for Mignot apparently wins the support of the Duke. Foreign experts are shortly invited to pass judgment, and over a year later, the Frenchman is still in good graces, as indicated by a letter of July 25, 1401, from the ducal secretary to the deputies of the Cathedral.⁶⁴ Further evidence of Mignot's influence is provided in the final conference held

62. The statement, ". . . hominis autem motus secundum locum quem vocamus lationem, aut rectus, aut circularis aut ex eis mixtus" obviously derives from a passage in *Physics*, VIII, 261b, 27, which is translated: "We are now to show that there actually is in nature, a motion ever-enduring, uniform and uninterrupted; and that its nature is that of rotation. *All local motion is circular or rectilinear or a combination of the two*, so that if either of these cannot be continuous, neither can any combination of them be so" (Loeb Classical Library, *The Physics*, tr. by Wicksteed and Cornford, London and New York, 1929). A passage in *De Caelo* (I, 270b, 25) states a similar principle, without considering the combination of the two. The manner in which these passages are applied to the design of the Cathedral indicates that they were either misunderstood or purposefully misused.

The word "rectus," which appears in this passage, is wrongly transcribed as "reclusus" in the *Annali*. Nava, *Memorie*, p. 96, provides the correct version.

63. The second reference to Aristotle is stated, ". . . idem dixit alibi omne corpus perfectum est in tribus." The reference is evidently to *De Caelo*, I, 268a, 20, which is translated: "In this sense, therefore, body is the only complete magnitude,

since it is the only one which is defined by extension in three directions, that is, which is an 'all.'" To clarify Aristotle's intention in this passage, one may refer to *ibid.*, 268a, 7: "Magnitude divisible in one direction is a line, in two directions a surface, in three directions a body. There is no magnitude not included in these; for three are all, and 'in three ways' is the same as 'in all ways'" (Loeb Classical Library, *On the Heavens*, tr. by Guthrie, Cambridge, Mass., 1939). Reference to this principle is made also in the *Metaphysics*, V, 1066b, 32, and VI, 1016b, 28. In referring to these passages the council has not only misused the source, but misunderstood it.

64. The letter is worth quoting as an impartial judgment of the controversies raging over the Cathedral: "Ad ipsius excellentissimi Domini nostri notitiam pervenisse displicenter quandam controversiam et discordiam jam diu versam inter suas cives Mediolani, occasione tam solemnis fabricae ecclesiae Mediolani, iterato renovari, videlicet per nonnullos allegari prefatam ecclesiam suam non habere rationem et mensuram nec fortitudinem respectu sequendorum in dicta ecclesia . . . per aliquos e contrario allegatur ipsam ecclesiam debitam rationem habere et mensuram ac proportionem et fortitudinem praedic-

under his leadership, on May 15, 1401.⁶⁵ Here the word-for-word transcription of the proceedings permits us to see that a majority of the masters take his part, but this reversal of the council's policy is probably due more to a change of personnel than to a change of heart.

This conference, not attended by Mignot, deals principally with his designs for the vaulting of the Cathedral. The debate is peculiarly bitter for, as one of the discussions proves, twelve to sixteen stones have already been laid, and sixty to seventy cut, for one or more vaults to be completed according to the original design.⁶⁶ Here the procedure is even more irregular than before, for a major change is considered for a portion already under construction. It is not possible to examine here the full text of this lengthy conference, nor is it necessary, for the many pages of heated argument serve to prove but one point: that neither the partisans nor the opponents of Mignot have the means of determining whether the proposed vaults are sounder or more desirable than those under construction. There is simply no common ground upon which varying attitudes may be discussed. The masters disagree on whether the new project is more solid; whether it is more "beautiful and praiseworthy"; whether it will cost more, and if so, how much, and whether the stones used must be larger or smaller than in the earlier project. The one problem which the "science of geometry" might be expected to solve without question is the last to be considered, and is stated, "vii Question: If, following the form of the second project, the work would be changed only with respect to the former dispositions concerning the maximum height or width of the church, or would its essential form be somehow changed?"⁶⁷ To our amazement, the question discloses that Mignot's project might involve a change in the proportions of the church itself—that here, at the last moment, the scheme of triangulation formulated nine years before is still open to revision. This question would seem to be formulated in a way that leaves no room for controversy, but the answers show the widest possible divergence of opinion concerning the effect of the project on the form of the church, as is evidenced by the following excerpts from the report.

Paderno: I reply that since the design presented by master Giovanni does not contain any indication as to the height of all the arches, as had been done by other engineers, I cannot reply concerning the height of the vault, only because he makes no sign of it on his design.

Serina: Replies that the main, center nave would become 8 braccia higher than that which was first arranged, after the design and the measurements given by master Giovanni, by whom a miracle must be in the making, since this same master Giovanni has said at other times that the whole edifice was not solid, and now, being even higher, it must needs be even less solid.

Calco: Replies that, following the form of the new project, one would not change the disposition already given relative to the maximum height and width, or relative to any substantial form, but only with respect to the maximum mass (*grossezza*) of the body of the church.

Della Croce: Following the form of the second project, one would change the false system already in place and respect the proper system of the triangle, which cannot be abandoned without error, as master Enrico and a certain german master Annex, before him, preached in former times with a high and faithful voice into the ears of deaf fools.

The remaining masters, with one exception, agree that certain changes in proportion are implicit in the project, but fail to specify what they may be. It is strange that the drawing which Mignot has presented for discussion gives no indication concerning the measurement of the vaults. Lacking any definite figures, let us tentatively assume that Serina's estimate of an 8-braccia alteration in

torum omnium respectum. . . . Considerantes altercationem et differentiam majorem solito oriri magis et procedere ex ignorantia inzigneriorum non expertorum nec se intelligentium circa necessaria fabricae, quam obstinatione suorum civium . . . deposuit, vult et mandat antelatus noster Dominus quod vos domini procuretis habere magistrum teutonicum de dicta fabricatione jam informatum, ac altios peritos et expertos inzignerios, qui cum Johanne Mignoto, perito et experto, ac aliis inzigneris ipsius fabricae se intelligant et taliter ordinent quod dicta ecclesia debito et suo jure et ordine procedat, defectus

corrigeno quam melius fieri potest . . ." (*Annali*, 1, 230f.).

65. *Ibid.*, pp. 224-229 (15 May, 1401).

66. *Ibid.*, p. 226. In answer to the question: "Qual numero di pietre poste in opera giusta il progetto già incominciato se dovrebbe rimuovere facendo il secondo?" one of the masters replies: "Sono circa 12 le pietre che bisogna rimuovere, e le altre già lavorate sono circa 60 o 70. . . ."

67. *Ibid.*, pp. 226, 227. Appendix VI. The text as given in the *Annali* is largely in modern Italian, probably translated from the Latin, although no indication of this is given.

the nave is correct. This is highly probable, for the previously established height of 76 braccia would thus become 84 braccia, which is, of course, just the height proposed by Stornaloco in 1391. In other words, Mignot has made an eleventh-hour attempt to restore the equilateral triangle. This interpretation fortunately helps us to explain the otherwise unclear statement of Della Croce, in which he pointedly favors the abandonment of the existing system of triangulation, and yet praises the new project because it "rispetta il retto ordine del triangolo." How can he be opposed to the triangle and yet support it? Obviously he makes a distinction between kinds of triangles: the *retto ordine* is the equilateral form, and the *falso ordine*, the Pythagorean compromise of 1392.

If Mignot's proposal actually restores the height of Stornaloco's design, it does so merely by raising the vaults themselves, and thus involves an even greater compromise than the 1392 solution, for these vaults must spring from capitals already constructed according to the earlier scheme. The result would be, so to speak, a Pythagorean sandwich on equilateral bread.⁶⁸ Mignot's supporters excuse this inconsistency by pointing out that he had no opportunity to reconstruct the church as it should be. This fifth and last in the series of solutions for the section is not employed. As has been indicated, the present Cathedral follows the scheme of 1392. Following this failure, we hear of Mignot only in connection with the accusations leveled at him, and the defense made in his behalf by his Milanese supporters. His dismissal on October 22, 1401, becomes a subject of controversy which continues well into the following year.⁶⁹

In retrospect, the history of foreign intervention which Mignot's departure brings to a temporary close, seems distinguished more by the failures than the successes of the visiting experts. Time and again northern masters expose the inadequacy of the entire structural system, attribute to it faults of the greatest magnitude, and leave, convinced that the work is destined to ruin. The Milanese plod stubbornly along, borrowing from the visitors here a superficial decorative device and there a geometrical phrase, but on the whole determined to accept no foreign solutions to the major problems in construction. While the piers may originally have been redesigned by Nicolas de Bonaventure, they are not altered to suit the demands of Parler and Mignot. The original foundations and buttresses remain unchanged despite criticism from both Italian and northern engineers, and the elevation of the Cathedral remains too low to satisfy anyone but a Lombard.

The fact that the contentions of the northerners appear sound, and that they are repeatedly voiced by numerous critics over a ten-year period, in itself prejudices us against the Milanese. Any doubts that remain are dispelled by a defense which is alternately absurd and unwise. Only one argument, and an incontrovertible one, speaks in favor of the Milanese: the Cathedral was built entirely according to their designs, and it stands. The poor foundations, weak piers, inadequate buttresses, undivided chapels, the *falso ordine* of triangulation, and vaults which "do not exert a thrust on the buttresses," have successfully survived five and a half centuries. Moreover, the present flying buttresses, which would appear to be the unique concession to northern criticism are, in fact, an addition of the late eighteenth and early nineteenth centuries.⁷⁰ In the mid-eighteenth century print reproduced in Figure 9, we see the upper portion of the Cathedral buttressed only by a low wedge of masonry. This is the crowning success of the Lombard Gothic system. Consequently, for all the learning of the northerners and the shocking and amusing ignorance of the Milanese, the

68. To increase the confusion, the 8-braccia alteration would change the vaults from 24 to 32 braccia in height, so it may also be said that the vaults, taken alone, are designed *ad quadratum*.

69. The week beginning October 15, 1401, is given over to vilifying Mignot. No other business appears in the records (*Annali*, I, 236-238). That there is some question as to the justice of his dismissal is apparent in a notice of November 27 (*ibid.*, p. 240), and a letter which warmly defends him is sent to the Duke on December 20 (*ibid.*, pp. xvif. of Preface,

dated February 1402, by Nava, *Memorie*, p. 130).

70. As I have indicated above, I believe that it was the intention of the designers of the Pythagorean section to dispense with flying buttresses, in accordance with Lombard tradition. The expertise translated in note 52 may be interpreted to suggest that they had not been projected before 1400. However, in 1410, they were definitely under consideration, as evidenced by the specifications given in a report of September 16 (*Annali*, I, 304).

Cathedral itself is evidence to the fact that the former were in error and the latter triumphantly justified. Their achievements rather than their words demonstrate that "science without art is nothing."

It is our great good fortune that we have in hand, not only evidence of the singular philosophy of mediaeval building which explains the late, provincial style of Milan Cathedral itself, but also a rich fund of information on the Gothic theory which undoubtedly prevailed throughout western Europe. In examining this theory, or, rather, *scientia*, we are first struck by the fact that it does not approach structural problems in a manner which we would regard as scientific. Mignot, for example, while recognizing the thrust exerted by a rib-vault, is unable to make even a vague estimate of its force, and demands buttresses of twice the necessary size. Moreover, having declared the structure inadequate to carry the vaults projected by the council, he proceeds to design vaults of his own which would have further increased the stresses. At no point in the various controversies over structure is either party to the debate able to provide reasons for believing that a given member will or will not serve its purpose. The northern experts simply draw upon their experience and on Gothic tradition, and attempt to reproduce northern forms at Milan, without consideration or understanding of the peculiar structural requirements of the Cathedral.

Such shortcomings suggest that to approach this *scientia*, it is necessary to put aside the predominantly mechanical or structural implications which the term "science" suggests to the modern mind. The *scientia* is not that of the modern engineer, but, to our way of thinking, a discipline larger in scope, if less effective in practice. In essence, it is based on the adoption of certain *a priori* formulae to which the entire structural *and* aesthetic character of a building must conform. The geometrical projects for the design of the section of Milan Cathedral immediately come to mind as the most striking example of the use of such formulae. Generally considered by scholars out of their proper context, they have been frequently misinterpreted.

The principal function of the geometrical formulae has already been suggested. They establish ideal figures for the whole which are reflected in consistent relationships throughout the parts of the Cathedral. Within certain limits the figures, and consequently the relationships, may be altered, as is demonstrated by the choice between the triangle and the square. Certain similarities between this approach and antique and Renaissance canons of proportion are evident, but it is of utmost importance for the understanding of our theory that we be aware of the differences. The classical system of proportions is what might be called organic. That is, a particular element such as a column is proportionately taller and wider in a large building than in a small one. The Gothic approach is what might be called abstract, and is comparatively unconcerned with proportions. Here the height and breadth of a particular element are determined only by a simple mathematical relationship to the whole scheme, and given this, the element may be relatively tall or short, wide or thin, according to the circumstances in which it is used. In essence, the difference is that a given element has no autonomous existence, but gains its form only by virtue of its logical association to the whole. Our *scientia* may thus be called a theory of consistent relationships. The tests to which it is put at Milan prove that, while it does not demand a particular proportion between the given width and the height of the Cathedral or its parts, it is highly critical of the mixture of triangular figures which disrupts the consistency of the relationships. Furthermore, it may be assumed that the interrelation of parts provided by geometrical formulae compensates for the Gothic engineer's ignorance of the laws of mechanics. In a sense, this interrelation is a symbol of structural stability. This function of geometry is emphasized by Mignot in the speech in which he emphasizes the importance of *scientia*, for he speaks of the "*scientia geometriae*" only in connection with structural problems: the support of the crossing-tower, and the thrust of a pointed arch. It is obvious that whatever knowledge Mignot has of stresses and thrusts is attributed to geometry. He consequently feels that a structure which does not conform to a simple geometrical figure is unsound. His late

design for the vaulting, which actually increases the thrust by raising the arches, is judged sounder than the earlier solution for the specific reason that it restores the equilateral triangle.

The contrast between the organic character of classical proportions and the abstract relationships of this *scientia* may be carried farther. Given the plan of an antique temple, one is able to reconstruct the elevation with fair accuracy. In contrast, given the plan of Milan Cathedral, even its architects are unable to agree upon an elevation. This may be partially attributed to inexperience, but is due principally to the limitations of an abstract theory. For the reason that no member of a Gothic structure has an autonomous existence, there is no established connection between plan and elevation or plan and section. It is this disconnection which makes a triangular and square section equally plausible for Milan's predetermined plan. For the same reason, once the position of a given member is established, there remains the problem of determining its extension. This is not a geometrical problem. The section *ad triangulum*, for example, represents a pier by a line, and a plan designed geometrically would represent it as a dot. We have already had an indication of the next step in the design. The *scientia* employs arithmetical formulae in much the same fashion as geometrical. Thus the thickness of the buttress is discussed in terms of a simple numerical relationship with the thickness of the piers, Mignot's 3:1 formula being opposed by the council's $1\frac{1}{2}$:1. By this means, two elements which are interrelated in elevation through the triangular formula are also interrelated in section through the numerical. How the breadth of the piers themselves was originally established is not discussed in the texts, but the answer may be found in the left-hand portion of Figure 7. The piers are 4 braccia wide and hence stand in a relation of 1:3 to the intercolumnar space of 12 braccia. While it appears irrational in terms of modern mechanics that the thickness of a buttress should be established in terms of the thickness of the piers, it is quite logical in terms of the theory we are examining, for this theory is built, not on forces, but on relationships.

These arithmetical formulae may also be employed for the establishment of relationships within a given member, as we have seen in the controversy over the pier capitals. We recall that Mignot and the Milanese disagree over the orthodox ratio between the base and capital (they argue 1:1 and 2:1 respectively), and that finally the unusual proportion of 1:4 is accepted. Now this controversy takes place after the piers have been raised. The 2-braccia height of the base has already been established, not in accordance with the height of the piers (which had not been determined when the bases were designed), but in accordance with their width of 4 braccia, to which its ratio is 1:2. Furthermore, the height of the shaft is established *ad quadratum*, in accordance with the width of the nave. Finally, when the capitals are discussed, they are related, not to the pier as a whole, but only to the bases. This rather confusing procedure is a consequence of a theory of interrelationships as against one of organic proportions. The form of the pier is determined by a series of discrete ratios.⁷¹

In summary, the *scientia* which we are examining is based on the employment of simple geometrical and arithmetical formulae, the purpose of which is to establish a complex of abstract relationships connecting the parts of a building to the whole, and interconnecting the parts. The theory is extremely sophisticated, but has one shortcoming which may be readily appreciated: given a problem which may be solved by two reasonable formulae of equal simplicity, there is no provision for determining which is preferable. Thus the problem of choosing a square or triangular section, or a 3:1 or $1\frac{1}{2}$:1 ratio of buttress to pier, may be solved only by considerations exterior to the *scientia*. It is here that the mediaeval builder calls upon *ars*. Questions which the theory is too abstract to answer are referred to traditional practice and to the mason's skill. *Scientia* and *ars* are the handmaidens of mediaeval building, and each plays its decisive role in the creative process. It is irrelevant to question which of the two is preeminent, and the controversy on this subject at Milan is

71. The reader will recall a further example of the numerical ratio in Stornaloco's sketch (*figure b*), where the height of the outer aisle is just half that of the nave.

evidence only of the "artistic" deficiencies of the northerners, and the "scientific" deficiencies of the Milanese.

Our consideration of this theory cannot be closed without reference to its strikingly apparent Platonic character. The actual Cathedral, being a compromise between *scientia* and *ars*, becomes in a sense, an imperfect imitation of the ideal Cathedral envisaged by *scientia*. A more obvious and direct influence of Platonic concepts is observable in the choice of geometrical formulae. As Dr. Frankl has pointed out, "Plato sanctified the equilateral triangle and the square,"⁷² and it is partially for this reason that the northern experts at Milan prefer these two figures as the basis for solving the problem of the section. By Platonic standards, the inconsistent triangulation of the present Cathedral is not only "falso," but ugly.⁷³ It is particularly interesting that, in view of the Platonic character of the theory, the Milanese should choose to employ Aristotelian quotations in their defense. As it happens, their confusion is such that they attempt to justify geometrical figures by physical and astronomical laws, but in more capable hands, the readjustment of Gothic *scientia* along Aristotelian lines might have had far-reaching consequences. By 1400, the Platonic theory of the northern architects had become academic, and tended to stifle the investigation of new possibilities in their art. It is only by virtue of ignoring this theory that certain successful experiments were made by the Milanese, though their lack of erudition prevented them from formulating a new *scientia* from their practice. Though it never came to fruition, it is exciting to speculate what an Aristotelian theory of architecture might have been.

In conclusion, let us return to our consideration of the position of the Gothic Rationalists, to determine whether, on the basis of the material we have examined, it may be said that "tout membre de cette architecture est la conséquence d'un besoin de la structure." First of all, we have seen that, regardless of the intentions of the architects of Milan Cathedral, the method of construction made it impossible for structural considerations to determine the forms of members. As we have consistently shown, almost every member was designed before its structural purpose had been determined. The entire plan was conceived for a cathedral considerably different from that which was erected; buttresses and piers rose toward an unknown objective, and finally the primary and basic structural problem, that of the vaults, was the last to be solved. At Milan, however, construction was carried on, to use Mignot's phrase, "in a fashion more willful than sound." It remains to be seen whether structural considerations would have been preeminent in determining the form of any other Gothic cathedral. If our northern *scientia* is any indication, it would appear that structure plays a secondary role in the process of creation. The over-all character of the Gothic cathedral is determined on the basis of geometrical grids of lines and dots in which the specific problems of form and structure play no part. Within this embracing pattern, the actual elements of the cathedral thereafter take shape by virtue of a compromise of ideal formulae and practical know-how. The mediaeval builder is evidently concerned with the problem of balancing theory (or *scientia*) and practice (or *ars*). In no sense is this equivalent to the distinction between structure and form. Structure and form are intimately related and interconnected in every step of the creative process.⁷⁴

In consequence, to impute to Gothic architecture a theory of "form follows function" is to make not only an error in interpretation but an error in method, for the dichotomy of form and structure so cherished by recent criticisms simply does not exist for the Gothic architect. The formulae of Gothic theory establish generalities of form and structure as one, while the methods of Gothic "art"

72. ART BULLETIN, 1945, p. 58.

73. Given sufficient evidence, it would undoubtedly prove that the choice of numerical formulae was similarly subject to aesthetic concepts of antique origin.

74. The discussions at Milan demonstrate the inseparability

of form and structure within the theory. Precisely the same arithmetical ratios are used in solving what might be called the purely formal problem of proportioning the pier capitals and bases, as are used in solving the predominantly structural problem of the mass of the buttresses.

particularize them. The modern argument of form versus structure is as meaningless as the mediaeval argument of *ars* versus *scientia*, for it likewise disrupts a partnership which can function only in happy union.

APPENDIX

I. 1392. Mercoledì, 1° Maggio

Coll'intervento di tutti gli ingegneri sottonominati —maestri, Giovanni da Ferrara, Zanetto da Binasco, Stefano Magatto, Bernardo da Venezia, Giovannino de'Grassi, Giacomo da Campione, Simone da Orsenigo, Pietro de'Villa, Enrico da Gamondia (qui non consensit), Lorenzo degli Spazii, Guarnerio da Sirtori, Ambrogio da Melzo, Pietro da Cremona, Paolo degli Osnago.

Omnes congregati in camera fabricae ecclesiae mediolanensis pro tollendis pluribus dubiis quae moventur super fabrica ipsius ecclesiae, quae dubia inferius distincte specificantur, et juxta dubia factae sunt responsiones et declarationes per omnes ipsos inzignerios, excepto ipso magistro Henricho, qui quamvis responsiones ipsae siti datae ad intelligendum, ipsis declarationibus nullatenus consensit.

Dubium.—Utrum partes ecclesiae tam posteriores quam collaterales et interiores, scilicet pilloni tam tiburii quam alii minores habeant fortitudinem sufficientem?

Responsio.—Deliberaverunt, responderunt et declaraverunt super eorum animabus et conscientis quod in praedictis omnibus et singulis est fortitudo sufficiens etiam ad majora sustinenda.

D. Utrum ipsa ecclesia debeat pluire in duobus tectis an in pluribus, proportionabiliter fiendis ab utraque parte usque ad croxeriam?

R. Deliberaverunt quod ipsa ecclesia debet et habet pluire pro majori fortitudine et claritate in tribus tectis et non in duobus.

D. Utrum ecclesia ipsa non computando in mensura tiburium fiendum debeat ascendere ad quadratum an ad triangulum?

R. Declaraverunt quod ipsa posset ascendere usque ad triangulum sive usque ad figuram triangularem et non ultra.

D. Quot brachia debent fieri pilloni servientes navi majori sive navi de medio?

R. Declaraverunt quod ipsi pilloni computando bases et capitellos debent ascendere brachia quadraginta et non ultra.

D. Quot brachia debent ascendere medii pilloni qui in muro fient super ipsis pillonis magnis usque ad volturas sive arcus super inde fiendos, et quot brachiorum debent esse volturae super ipsis fiendae?

R. Deliberaverunt et declaraverunt quod medii pilloni sint brachiorum duodecim, et volta ipsius majoris navis ascendat ad triangulum, videlicet brachia viginti-quatuor.

D. Quid sibi videatur de designamento unius portae gemellae croxeriae versus Compedum cum tota facie ipsius croxeriae?

R. Ea visa et perspecta declaraverunt quod ipsa est valde pulchra et bona ac honorabilis, et quod super ea procedatur.

D. Utrum debeant mediari sive intramezari capellae ipsius ecclesiae muro, una ab altera, nec ne?

R. Declaraverunt, quia non egent ipsae capellae aliqua alia fortitudine, quod remaneant et fiant sine alio medio, seu sine muro mediano.

D. Utrum debeat fieri una sala sive unus corraitor supra secunda navi, quae est inter navim magnam et capellas ecclesiae?

R. Dixerunt quod ipsa sala nullatenus est fienda quia occupat aerem et adducit expensas.

D. Utrum sit procedendum ad laborandum pillonos sive contrafortes exteriores prout est incoeptum, an aliquid innovari?

R. Dixerunt quod id opus sibi placet, et quod non est aliquid mutandum, ymo est procedendum ad laborandum.

D. Utrum debeat procedi super pillonis guerziis an aliquid de eis dimoveri vel commutari?

R. Deliberaverunt quod ipsi pilloni, quia suas debitas proportionales et membra habent, non sunt movendi, ymo perficienti et affinandi.

D. Quot brachia debent ascendere pilloni minores sive pilloni capellarum et medii pilloni, qui cum muro super eis fieri debent usque ad archus respondententes versus navem magnam?

R. Responderunt et declaraverunt quod illi minores pilloni debent esse alti brachia 28, et medii pilloni super eis construendi usque ad archus sint et esse debeant brachiorum 12, computatis in ipsis mensuris bases et capitellos.

(*Annali*, I, 68, 69)

Ia. 1392. Giovedì, 2 maggio

Tutti gli ingegneri intervenuti nella seduta di jeri confermano in ogni sua parte quello che è scritto più sopra, eccettuato Simone da Orsenigo il quale vi consente in massima, fourchè dice doversi le cappelle della chiesa tramezzare con muro nello stesso modo con cui sono state collegate sotto terra.

(*Annali*, I, 69)

II. 1400. Domenica, 11 gennaio

Deliberarono pagarsi i notaj, che scrivono i difetti e rimedii necessari per la fabbrica dietro la requisizione dell'ingegnere Giovanni Mignoto di Parigi. Le dette note sono come segue:

1. Dubbi elevati dal Mignoto, e risposte degli ingegneri della fabbrica:

Item piloni qui habent manutenere et sustinere dictam ecclesiam a parte posteriori inter magnas fenestras sunt debiles per modum quod expedit duos alias pilones remediabiles apud illos facere, nec adhuc ipsis duobus factis et ea pars ipsa ipsius ecclesiae erit fortis sicut deberet esse.

Respondunt ipsi magistri quod habita informatione et deliberatione cum pluribus et discretis personis, qui

interfuerunt fundamentis dictae ecclesiae, et qui per sacramentum eis delatum in manibus dominorum vicarii provisionum et multorum aliorum sapientium fabricae praedictae, et qui laboraverunt ad faciendum fundamenta ecclesiae a parte posteriori et in aliis partibus, et qui per suum sacramentum dixerunt praedictum opus est bene fundatum cum sit profundatum per br. XIV (*sic*) usque ad anixium, et quod in primo cursu positi sunt lapides magni sarrizii et sunt retracti in dicto fundamento, et in multis aliis partibus sunt inclavati magnis lapidibus sarrizii, et quod super dicto fundamento ex dictis brachiis XIV vel id circa sunt brachia tria cum dimidio et quatuor pro adequato sarrizii computata bancha et retracta banchae usque ad marmorem est brachium medium vel id circa. Item retracta cornixiarum marmoris est quartarum trium cum dimidia usque ad murum rectum et murus contrafortum et pilonorum simul se tenentium cum aliis est de lapidibus marmoreis intus ecclesiam et extra, et in medio piloni sunt lapides sarizii bene splanati et bene clavati, et ad majorem fortitudinem sunt clavati cum clavelis ferri pomblatis ubique. Et praedicta omnia patent. Et ulterius praedicti magistri volunt super capitellis ponere ferros seu strictores ferri magnos qui inclavent unum pilonem cum altero et ita fiat ubique per totam ecclesiam. Et super dictis capitellis deliberaverunt prout deliberatum est fieri facere archus spigutos secundum ordinem datum per multos alios inzignerios bonos et expertos, inde dicunt quod archi spiguti non dant impulsam contrafortibus, et rationibus praedictis concludunt omnes contrafortes esse fortes et sufficientes ad majus onus, quapropter non indigent facere contrafortes ecclesiae in nulla parte.

(*Annali*, I, 202, 203)

IIa.

8. Item quod ex illis pilonis viginti duobus qui sunt infra crucem et navem dictae ecclesiae adsunt piloni decem et octo, qui non respondent prout correspondere debent ad suam rationem debitam, alii vero quatuor piloni qui sunt posteriores bene se respondent.

Dicunt et respondent quod piloni quos ipse magister Johannes asserit esse XXII et non sunt nisi XXI qui appareant, inter quos adsunt quindecim qui respondent ad suum quadrum bene ordinatum, alii vero sex respondent ad retundum secundum suum ordinem.

(*Annali*, I, 203)

IIb.

9. Item quod capitelli pilonorum positi in opera supra ipsis pilonis non sunt positi ad rationem suam, quia pedes ipsorum pilonorum sunt brachiorum duorum pro quolibet in longitudine, et capitelli sunt br. X pro quolibet ipsorum in longitudine, debent esse ipsi capitelli tantae longitudinis quantae sunt pedes ipsorum pilonorum.

Dicunt et respondent quod pedes sive bassae pironorum si sunt brachiorum II capitelli debent esse brachium unum, ipsis rationibus dicunt bassam pironorum et pes dicitur pes hominis et capitellum dicitur caput piloni, ita caput hominis dicitur a capitello. Ita quod pes est quarta

pars capitis hominis et per istam rationem naturalem deberent esse brachia VIII et si essent facti de br. X essent propter ad ornamentum pironorum pro ponendo figuras.

(*Annali*, I, 203, 204)

III. 1400. Domenica, 25 gennaio

Magister Johannes Mignotius de Parisiis dixit in consilio praesenti dedisse in scriptis usque nunc computata caedula per eum data in consilio praedicto omnes rationes et omnia motiva per quae vult dicere praedicta opera non habere fortitudinem et alias rationes non velle dicere.

Capitula ultimata data per suprascriptum magistrum Johannem de die 25 januarii.

1. Vobis egregiis dominis de consilio fabricae ecclesiae Mediolani cum reverentia et pura veritate significat magister Johannes Mignotius quod, sicut alias et inter alios defectus dictae ecclesiae exhibuit in scriptis, iterato dicit et proponit quod omnes contrafortes circum circa dictam ecclesiam non sunt fortes nec habiles ad sustinendum onus quod eis incumbet quia debent esse tribus vicibus pro quolibet grossis quantum est grossus unus pilonus de intus ecclesiam.

Magistri respondent:

Supra primo capitulo dicunt quod omnes contrafortes dictae ecclesiae sunt fortes et habiles ad sustinendum suum onus et plus multis rationibus quia unus brachius nostri marmoris et sarizii in quolibet latere est tam fortis sicut brachia duo lapidum Franziae vel ecclesiae Franziae quam dat in exemplum suprascriptis magistris. Qui inde dicunt quod si sunt et sunt totidem et medium quotidem sunt piloni intus ecclesiam praedictos contrafortes esse fortes et esse ad suam rationem, et si fuissent majores obscurassent ecclesiam praedictam obstante, videlicet ecclesia Parisiis, et quae habet contrafortes ad modum magistri Johannis et aliae rationes quia nocuisse possunt.

2. Item dicit quod quatuor tures sunt incoepae pro sustinendo tiburium dictae ecclesiae et non adsunt piloni nec aliud fundamentum habiles pro sustinendo dictas tures, imo si ecclesia esset facta in toto illico cum dictis turribus infalibiliter rueret, super iis vero quod certe per passiones factae sunt per aliquos ygnorantes allegantes quod voltae acutae sunt plus fortes et cum minori onere quam voltae retondae, et plus super aliis propositum est ad voluntatem quam per viam virtutis; et quod est deterius oppositum est quod scientia geometriae non debet in iis locum habere eo quia scientia est unum et ars est aliud. Dictus magister Johannes dicit quod ars sine scientia nihil est, et quod sive voltae sint acutae sive retondae non habendo fundamentum bonum nihil sunt, et nihilominus quamvis sint acutae habent maximum onus et pondus.

Item dicunt quod tures quos dixerunt sibi velle facere dicunt pluribus rationibus et causis, videlicet, primo pro retificando praedictam ecclesiam et croxeriam quod respondent ad quadrangulum secundum ordinem geometriae; alia vero pro fortitudine et pulchritudine tiburii, videlicet quasi per istum exemplum in paradiso

Dominus Deus sedet in medio troni, circha tronium sunt quatuor evangelistae secundum Apocalissim, et istae sunt rationes quare sunt incoepae. Et quamvis non sint fundati duo piloni pro qualibet sacraestia incipiendo super terram, ecclesia est tamen fortis bene istis rationibus, quia repressae super quibus dicti duo piloni et praedictae repressae sunt de magnis lapidibus et inclavatis cum clavibus ferri sicut dictum est supra cum aliis capitulis, et quod pondus dictis tribus turribus ponderat ubique super suum quadrum, et erunt aedificata recte et fortiter, sed rectum non potest cadere; unde dicunt quod sunt fortes per se et ergo dabunt fortitudinem taborio, quia clausus est in medio illarum turrium unde dicta ecclesia bene fortis est.

3. Item cognoscit quod voluntarie agitur in praemissis nec contradicentes volunt condescendere juri et meliori dictae ecclesiae et fabricae, sed volunt aut per eorum lucro aut timore, quia voluerunt consequi fabricam super defectibus, aut obstinatione vincere causam, et pro tanto petit dictus magister Johannes committi debere IV vel VI vel XII ex melioribus inzigneris expertis in talibus, sive de Alamania, sive de Anglia, sive de Franzia, cum aliter dicta fabrica ruet pro certo, quod erit magnum damnum universimodo. Uterius pro veritate evidenti et sui honoris conservatione accedere vult ad presentiam illustrissimi domini Domini et eidem praedicta et alia latius explicare—Item significat quod pro bono ecclesiae foret bonum alibi laborare in dicta ecclesia quam super locis defectuosis saltem usquequo fuerit clare provisum et decisum super istis defectibus.

Item dicunt et respondent in eodem capitulo quod ubi dicit quod scientia geometrica non debet in iis locum habere, dicunt suprascripti quod si hoc testante videlicet per regulam geometriae Aristotulus dixit hominis autem motus secundum locum quem vocamus lationem, aut reclusus aut circularis aut ex eis mixtus. Item idem dixit alibi omne corpus perfectum est in tribus et motus ipsius et dictae ecclesiae ascendit ad triangulum ut jam declaratum fuit per alios inzignerios, unde dicunt quod omnia sunt per rectam lineam, aut per sextum, ergo concluditur quod quae facta sunt, sunt facta per geometriam et per praticam, quia ipse dixit quod scientia sine arte nihil est; de arte autem jam responsum est in aliis capitulis.

(*Annali*, I, 209, 210)

IV. 1400. Addi 21 febraio

In nomine Domini 1400 die 21 februarii.

Fuerunt in domo reverendissimi in Christo patris domini Archiepiscopi Mediolani in ipsius praesentia et plures ex deputatis et consilium fabricae ecclesiae majoris Mediolani fuerunt interrogati Simonetus Nigrus, Johannes Sanomerius, et Mermetus de Sabaudia, omnes tres inzignerii francischi, in et super infrascriptis quaestionibus et artichulis infra nominatis, quod debeant dicere et determinare pro suo sacramento et pro viagio quod faciunt eundo Romam.

Imprimis interrogaverunt super istam quaestionem suprascriptos dominos si ipsis videbatur quod dicta ec-

clesia esset sufficienter fundata pro sustinendo et portando onus pertinens dictae ecclesiae.

Nos supradicti inzignerii et operarii massonariae discimus quod nos visa et revisitata tota dicta ecclesia, et spetialiter vidimus discopertum fundamenta duorum pilonorum, qui duo piloni debent sustinere et butare contra culatam ipsius ecclesiae, qui sunt parviter et male fundati, et ad falsum unus talis est interius operis plus de uno pede, et de mala materia, et quod omnes piloni dictae ecclesiae intus et extra sint revisitati usque ad minimum fundum et omnes qui erunt male fundati ut suprascripti sunt sint refundati de magnis quarteribus lapidum bene jacentium et lectus sit bene drizatus et planatus et bene jungeneos et butatis per apalattas intus aliis fundamentis bene intus et massonatis ad bagnum de morterio, et dicti fundamenti fiant de duobus brachiis vel plus ultra plumbatis bassarum pilonorum veniendo per reotractam in superficie ad unum brachium.

Item interrogaverunt et fecerunt quaestionem si suprascripti duo piloni extra culatam dictae ecclesiae sunt satis fortes pro sustinendo et butando contra totum suum onus.

Nos discimus quod qui funderet duos pilonos pro portando duos archos butantes quod ecclesia redderetur fortiorem sed pro minori impedimento discimus quod refundaret de novo ad unum pondum de magnis quarteriis lapidum bene, et goger, et gont, idest bene quadras et junctas et assisas ad bagnum de morterio de quatuor brachiis butatis totum ac longum usque ad superficiem terrae, et dictae lapides sint butatae de subtu aliud fundamentum per apalattam, et de sumitate terrae in sursum allungando seu alargando dicti duo piloni de brachiis duobus usque ad ipsorum altitudinem et sint inclavatae novae lapides cum veteribus, et isto modo nos putamus quod possint portare suum onus.

Item interrogaverunt et fecerunt quaestionem si omnes alii piloni dictae ecclesiae nobis videntur esse boni.

Nos discimus quod si essent adhuc fiendi possent fieri meliores.

Item interrogaverunt si omnes supradicti piloni possunt portare et passare suum onus sicut sunt.

Respondimus quod nobis videtur quod sic unum habeant unum bonum magistrum operarium massoneriae qui fiat cambiare moluras et carichas de super capitella, et faciendo ipsa molura bona et levia pro causa, quod aliqui dictorum pilonorum non sunt bene aligniati et hoc est pro ponendo ipsas ad suam rationem taliter quod non perpendatur de eorum mala facione et pro minus charichando.

Item discimus quod naufrati sunt et forati de foraminis retondis piloni cornerii sacrastrarum dictae ecclesiae pro portando foris aquas pluvianas descendentes de copertura sacrastrarum et cappellarum, et est contra rationem, et oportet quod claudentur et massonentur et fiant alias novas gargolas quae portabunt suas pancas et novae, et brodes, pro recipiendo dictas aquas et facient subbassamentum pro corotoro factum ad claritatem. Symonetus Nigrus, Johannes Sanomerius, et Mermetus de Sabaudia.

(*Annali*, I, 211)

V. 1400. Addi 8 maggio

Al nome de Deo e dela Vergine Madona Santa Maria de l'anno del mille quatrocento adi 8 di Mazo. Io Bertholino da Novara el quale sono stato mandato per lo illustro et excelso principio signiore messere lo duca per certe openione e differentie mosi per alchuni maestri in la fabrica e maisterio dela giesia de Madona Santa Maria, le qualle differentie et openione li deputati dela dicta fabrica a mi hanno dato per scripto, le quale ho veduto, e examinato, e oltra questo sono stato cum li magistri e inzignieri, li quali sono al presente in la dicta fabrica, a vedere a ochio de sotto, e de sopra le deferentie de la dicta giesia. Et oltra quello vedere ho facto cavare in certi lochi li fondamenti de la dicta giesia per vedere li dicti fondamenti per essere più giaro deli dicti dubii mosi ala dicta fabrica; in breve rispondendo digo che la giesia potrave aver habiudo in tre li fondamenti, e in alchuni altri lochi supra terra più debita proportion. Ma per questo non se po biassimare, anche se de lodare per uno belentissimo edifitio e grande, ma secundo el mio parere serave de bisogno per eterna fortificatione fare questa adgiunta overo additione zoè:

In prima perchè li contraforti del corpo dela giesia non hanno tuta quella grandezza che sareve de bisogno, considerando la largheza e l'alteza dela dicta giesia, vorave se reduze la prima nave in forma de capelle cum le mezure tra l'una capella e l'altra cum alchuni straforti, per li quali se porave vedere el corpo de Cristo da l'uno con l'altro de la giesia, e fazendo così vegniarevese a dare grandissima forteza ale altre tre nave per quilli archi butanti averave più fermo el suo principio e el corpo dela giesia parerave più bello, e più con sova rexone per che el seguireve la grandezza de la cruxe.

Item serave de bisogno fare una capella in la culaza de la giesia verso el campo santo, la quale capella se acostaze a quelli dui contraforti da el lado de drecto fazando la minore che se possesse. e non guastando alchuna cossa de quello chi è facto, e per questa capella seguirave più forteza, e in questa capella porave se reduze quella archa, che se dixè che vole fare fare lo el signiore messere lo duca, e siando reducta l'archa in lo dicto locho poravese ponere più in drecto, cel cor vegniarave a essere più grande.

Item digo che per queste additione o sia zonte non starava de fare lavorare e livrare le parte principale, e seguire la maynera principiada e comenzada. Magistro Bernardo da Vanezia, magistro Bertholino da Novara.

(*Annali*, I, 213)

VI. 1401. Domenica, 15 maggio

VII. Domanda: Se seguendo la forma del secondo progetto si muterebbero soltanto per questa opera le pre-

cedenti disposizioni circa la maggiore altezza o larghezza della chiesa, od in qualche sua forma sostanziale?

Carona: La risposta è che si varierebbe l'ordine stabilito dagli altri ingegneri, secondo il già principiato.

Paderno: Rispondo che siccome il disegno presentato da maestro Giovanni non contiene alcuna dimostrazione circa all'altezza di tutti gli archi, come era stato fatto dagli altri ingegneri, così non posso rispondere intorno all'altezza della crociera, se non che esso non ne fece cenno nel suo disegno.

Serina: Risponde che la navate principale di mezzo andrebbe ad essere di 8 braccia più alta di quello che era stato disposto prima, giusta il disegno e la misura datine da maestro Giovanni, per cui deve far meraviglia se altre volte lo stesso maestro Giovanni disse che non era solido tutto l'edificio, che ora essendo ancora più alto dovrebbe essere meno solido.

Calco: Risponde che seguendo la forma del nuovo progetto non si varierebbe la disposizione già data relativamente a qualche forma sostanziale, ma solamente quanto alla maggior grossezza del corpo dell'edificio.

Donato: In confronto di quella prima ordinata si fa qualche variazione all'altezza compiendo il progetto Mignoto, ma questa variazione è lodevole perchè segue la ragione geometrica del triangolo.

Alcherio: Se non erro, col progetto Mignoto si fa qualche variazione nell'altezza, ma qualunque variazione succeda per lo stesso, sarà un miglioramento della solidità, della congruità, della bellezza, e della celerità di costruzione della fabbrica, e ciò riescirà un gravissimo documento contro i ciechi che fingono di essere geometri.

Della Croce: Seguendo la forma del secondo progetto si muta il falso ordine già disposto, e si rispetta il retto ordine del triangolo, che non può essere abbandonato senza errore, come altre volte maestro Enrico, e certo maestro Annex tedesco, prima di lui, predicarono con alta e fedele voce nelle orecchie dei falso sordi.

Scrosato: Rispondo che se si varia qualche disposizione precedente, la si varia in meglio, in più bello e più lodevole modo, secondo la geometria triangolare.

Galletto: Dico che seguendo il nuovo progetto si muterebbe la disposizione precedente, ma questo non si allontana dalla forma triangolare, dalla quale nessun geometra perito non può ne deve recedere, cosicchè anche con qualche variazione non si abbandona la suddetta forma triangolare, ciò che vidi fatto anche da altri maestri periti in simili cose.

Cavagnera: Dicho che otegniando lo modo di magistro Johanne, zoè per li archi e croxere tanto che la nostra gexia non andava ni più bassa ni più alta, nè si difformava a nessuna provvisione data in fata.

(*Annali*, I, 227)

[NEW YORK UNIVERSITY]