The "Dimensional Inconsistencies" of the Plan of Saint Gall
and the Problem of the Scale of the Plan

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To Richard Krautheimer at seventy

1. The "Dimensional Inconsistencies"

In the 1963/1964 issue of the Zeitschrift für schweizerische Archäologie und Kunstgeschichte, Adolf Reinle came forth with a new interpretation of the internal inconsistencies of the explanatory titles which define the dimensions of the church on the plan of Saint Gall. This theory is in response to certain textual incongruities which have haunted many other students of the plan. Among the more than 340 legends on the plan, which define the purpose of its buildings, their respective rooms and furnishings, there are five which list dimensions and all of these are within the church (Figs. 1, 2). They are:

1. In the longitudinal axis of the church, written in capitalis rustica, in groups of two and three letters, so as to extend the entire length of the building:

   AB ORI EN TE IN OC CI DEN TĒ LON GIT· PED ·CC-

traditionally transcribed as:

   AB ORIENTE IN OCCIDENTE[M] LONGIT[UDO] PED[UM] CC-

   and accordingly translated:

   "FROM EAST TO WEST THE LENGTH [IS] 200 FEET."

2. In the nave, written crosswise, midway between the altar of the Holy Cross and the ambo (Fig. 2):

   Latitudo Interioris tepli pedū x l
   "The width of the nave [is] 40 feet."

3. In the aisles, in line with the preceding title (Fig. 2):

   Latitudo utriusque porticus pedum xx
   "The width of each aisle" "[is] 20 feet."

4. Between the interstices of the columns of the nave arcades (Fig. 1):

   Bis senos metire pedes interquæ columnas (southern row)
   Ordine quas isto constituisse decet (northern row)
   "Measure twice six feet between the columns"
   "In this order they shall be arranged."

5. In the interstices of the piers of the Western Paradise (Fig. 1):

   Has interque pedes denos moderare columnas
   "Between these columns [or piers] measure ten feet."

It has been observed by many other students of the plan that a conflict exists between the figures defining the width of the church and those which are given for its length. If a scale is constructed on the basis of the 40-foot width of the nave and applied to the length of the church, the overall dimensions of the latter would come not to 200 feet (as is stipulated in No. 1), but to 300 feet; and if the same 40-foot scale were applied to the interstices of the two great columnar orders, the axial distance from column to column would not amount to 12 feet (as stipulated in No. 4), but to 20 feet, since the drawing shows this span as being exactly one-half the width of the nave.

Reinle proposes to solve the conflict between No. 1 and No. 2 by a new interpretation of the meaning of No. 1. The latter is, in his opinion, not the designation of a simple linear dimension, but a definition of the ratio of the dimensions of the drawing to the dimensions which the church was to obtain on the ground. The meaning of the axial title of the church, accordingly, is not, as generally assumed: “FROM EAST TO WEST THE LENGTH [IS] 200 FEET,” but rather, “THIS PLAN IS DRAWN AT THE SCALE OF 1:200.” Reinle arrives at this interpretation in the following manner:

1. PED, he maintains, must not be transcribed as PEDUM
   (genitive plural of pes = “foot”), but as PEDA or PEDIA

NB A bibliography of frequently cited sources, given in short form in the footnotes, will be found at the end of this article.
* The analytical drawings and architectural reconstructions which illustrate this article are the work of Ernest Born. The responsibility for the views set forth in this study is Walter Horn's.
(imperative form of the verb pedare or pediare = “to measure in feet”).

2. LONGITudo must not be read as LONGITudo (nominative of the noun longitudo = “length”), but as LONGITUDINE (ablative form of the noun longitudo = “in length”).

3. ‘CC’ is not the simple cardinal figure ducentum = “two hundred,” but must be interpreted as a multiplicative term, in the sense of ducenties = “two hundred times.”

Reinle, accordingly, transcribes the title:

AB ORIENTE IN OCCIDENTEM LONGITUDINE PEDA DUCENTIES,

and purports this to mean “FROM EAST TO WEST, IN LENGTH, MEASURE TWO HUNDRED TIMES,” or “THIS PLAN IS DRAWN AT THE SCALE OF 1:200.”

This interpretation is untenable on two counts: (1) it is based on an improper textual exegesis, and (2) it ascribes to the ninth century a method of defining architectural scale relationships which does not antedate the French Revolution.

To begin with the first of these two objections, it must be noted that Reinle’s interpretation of the axial title of the church has been undertaken without reference to the latinity of the other titles of the plan and their system of graphic abbreviations. The plan is furnished with some 340 separate entries of varying length, the majority in prose, the remainder in verse. The prose is lucid and not susceptible to misinterpretation at any point. The verses are often somewhat flowery in style, but their syntax and sense is always clear. There is nothing equivocal about the distich which defines the interstices between the columns of the nave arcades (No. 4) or the hexamer which defines the interstices between the piers of the Western Paradise (No. 5). And there is nothing equivocal about the style or syntax of any of the other titles of the plan. It is inconceivable within the total context of these legends that the drafter of these texts would have framed one of the most crucial lines of his commentary in such a sloppy manner as to mislead some seven generations of Latinists into interpreting as a simple designation of length what he meant to be a ratio of scale.

If PED had been meant to stand for PEDA (imperative form of pediare), the scribe would have found himself compelled to make this clear by spelling the word out, in view of the fact that PED is the traditional abbreviation for PEDUM (genitive plural of pes). By the same token, he would have had to have made it clear that LONGITudo stood for LONGITUDINE, rather than allowing it to be read as LONGITudo. And if the capital letters CC were meant to convey the meaning “two hundred times,” rather than the figure 200, the scribe would have had to have made this clear, as such a use of the letters would have differed distinctly from their traditional usage. The need for this would have been the more pressing because clearly all of the other dimensional titles on the plan are designations of simple linear length. No reader of the plan can fail to notice that the syntax of the longitudinal title of the church (No. 1) and the two titles which describe the width of the nave and the aisles (No. 2 and 3) is identical. Each consists of a subject (LONGITudo, Latitudo, Latitudo), a prepositional phrase (AB ORIENTE IN OCCIDENTEM, interrioris templi, utriusque porticus), and a predicate phrase (PEDUM ‘CC’, pedum xl, pedum xx). The verb est is missing, but implicit in the text, and it is, therefore, entirely proper to translate these respective passages as:

1. “FROM EAST TO WEST THE LENGTH OF THE CHURCH IS 200 FEET”
2. “The width of the nave of the church is 40 feet”
3. “The width of each aisle . . . is 20 feet.”

What, then, induces Reinle to engage in such arbitrary textual exegesis? Reinle believes he has discovered that the plan of Saint Gall was drawn at a scale of 1:200. He is not the first to advance this view. Wilhelm Rave expressed himself along similar lines in 1956, and Emil Reisser likewise in a posthumous study published in 1960.

The plan is, indeed, drawn to a scale which comes close to what today we would define as a ratio of 1:200. But it is one thing to observe that the plan was drawn at a scale which corresponds or comes close to the ratio of 1:200; it is quite another to claim that it was actually drawn at that scale. In proposing this view, Reinle is caught in an anachronism. The concept 1:200 is not a mediaeval concept and does not make sense within the mediaeval system of mensuration. If a modern architectural drawing is said to have been laid out at a scale of 1:200, this means that one unit on the drawing corresponds to 200 identical units on the ground. The base of

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3 Reinle, loc. cit.
5 Reinle, “St. Galler Klosterplan,” 93, 98.
7 Emil Reisser, Die frühe Baugeschichte des Münsters zu Reichenau (Forschungen
this ratio is decimal. A mediaeval architect could not have expressed himself in these terms, since the two basic units of measurement with which he worked, the foot and the inch, were internally divided not into tenths, but into twelfths and sixteenths (a system which still persists in England and the larger Anglo-Saxon world) or into twelfths and sixteenths (the pied royal de France, which was used in France until the introduction of the metric system).  

The foot and its primary subdivision, the inch, were derived from the human body. Twelve thumb-breadths of a fully-grown man equal the length of his foot (text fig. 1). This is the raison d'être for the twelve units of the English foot. The French word pouce, Old French poulée, Latin pollex, all meaning "thumb," reflect the history of the genesis of this measure. Like the English foot, the Latin foot consisted of twelve inches. "Inch," Anglo-Saxon ynce, comes from Latin uncia = "a twelfth"; and the duodecimal graduation of the Roman foot is reflected in the series: uncia = 1/12th; sextans = 2/12ths or 1/6th; quadrans = 3/12ths or 1/4th; triens = 4/12ths or 1/3rd; quinuex = 5/12ths; semipes = 6/12ths or 1/2; septunx = 7/12ths; bes = 8/12ths or 2/3rds; dodrans = 9/12ths or 3/4ths; dextans = 10/12ths; and deunx = 11/12ths.  

For divisions smaller than the breadth of a thumb, the human body does not offer reliable guidance. These smaller units could only be obtained by instrumental operations, and the simplest, easiest, and for that reason, probably the oldest way of graduating a distance into a sequence of consistently decreasing smaller units is the method of continuous halving—a procedure by means of which a whole is reduced to a half, a half to a quarter, a quarter to an eighth, and an eighth to a sixteenth (text fig. 2). This is the procedure that created the sixteen graduations of the English inch. The sedecimal graduation of the inch, to judge by its tenacious survival in the modern Anglo-Saxon world, must have been the traditional way of subdividing inches in mediaeval England. It may very well also have been the traditional way of graduating the inch on the Continent. But in France there existed, in addition, at least one system of measurement in which the inch was subdivided into twelfths, the pied royal, in which the foot was subdivided into twelve pouces, and each pouce again into twelve lignes. We know nothing about the internal divisions of the Carolingian inch, but whether it was graduated into twelfths or into sixteenths, this much is certain: there was no common decimal denominator between a Carolingian inch and a Carolingian foot that could be expressed in the ratio 1:200.  

The modern metric scale is based on a comparison of parts of like nature, all of which can be understood either as fractions or as multiples of ten. The mediaeval scale has no such common unit of reference. It is a combination of a variety of different forms of graduation (sedecimal, duodecimal, and decimal), whose relation to one another cannot be expressed in the terms of a decimal sequence. It would be correct to

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8 For general information see the articles "Weights and Measures" in Encyclopaedia Britannica, and "Poids et Mesures," in Grande Encyclopédie, xxvi Paris, n.d., 1194-96 as well as the literature there cited.

9 With regard to the Roman foot see the article "Piede" by Luigi Jacone, in Enciclopedia Italiana, xxvii, Rome, 1925, 1471; for a fuller account, Friedrich Hultsch, Griechische und römische Metrologie, Berlin, 1862 and Angelo Segré, Metrologia e circolazione monetaria degli antichi, Bologna, 1928.

say that the plan of Saint Gall is drawn to a scale in which 1/16th of a Carolingian inch on the drawing corresponds to one Carolingian foot on the ground. To convert this into a relationship in which the ratio is expressed in the form of like units requires that the base value of 1/16th of an inch be multiplied first by 16 (the sixteen parts of the inch) and then by 12 (the twelve parts of the foot): 16 × 12 = 192. There are 192 sixteenths of an inch in a foot. The ratio 1:192 is not far from the ratio 1:200, but it is not identical with it and should, under no circumstances, be confused with it.11 In mediaeval mensuration the scale relationship 1:200 not only did not exist; it would have been meaningless. The figure 200 is not a natural break in a system which is based on fractions of 12 and 16. It acquired meaning only after the adoption of the metric system—a system of consistently graduated units of like dimension which departed so radically from the chaotic, but deeply ingrained, forms of mensuration which it supplanted that it could have been inaugurated only under the auspices of a political revolution and enforced by the mandate of an ensuing dictatorship.12

Reinle made an attempt to calculate the Carolingian foot which was used in the layout of the site and the buildings of the plan of Saint Gall. He arrived at the disconcerting conclusion that the drafter of the scheme made use of no less than three different scales:

1. a foot equivalent to 34.0cm, which determined the dimensions of the church and the cloister,

2. a foot equivalent to 29.2–29.7cm, used in the construction of the novitiate and the infirmary, and

3. a foot equivalent to 30.0cm, used in the planning of the guest and service structures of the monastery, as well as the monks’ cemetery and garden.15

I am venturing to add to this a fourth possibility, the conjecture that all of these calculations are wrong. They are in fact not calculations; they are plain guesses. They are advanced not on the basis of a thorough and exhaustive scale analysis of the plan, but on the simple assumption that certain key dimensions of the plan—such as the length of the church or the width of the cloister yard—correspond to certain demarcations on a straight-edge graduated in Carolingian feet, the precise value of which is unknown. Reinle observed correctly that the 40-foot width of the nave of the Church corresponds to 6.7–6.8cm.16 This he considers to be the equivalent of one-fifth of a Carolingian foot: 33.5–34.0cm. Here again he allows himself to be trapped in an anachronism. The mediaeval foot, as has already been amply stressed, was not divided into fifths, but into twelfths. Reinle’s reason for believing that the large building to the east of the church, which contains the novitiate and the infirmary, was drawn on a scale different from that used in the layout of the church is that none of the principal internal parts of the novitiate and the infirmary can be understood as a fraction of the Carolingian foot of 34.0cm.17 The answer to this is very simple. It cannot—because Reinle’s reconstitution of the Carolingian foot used for the construction of the church was wrong. The same criticism can be extended to the other deviational scale which Reinle purports to recognize in the layout of the guest and service structures of the plan of Saint Gall.

Reinle’s theories, then, turn out to rest on deplorably shaky ground. They appear to me to be the more unfortunate, as they lead to the inference that the plan is not the product of a single creative act, but a compilation of heterogeneous parts derived from different sources.18 This is not the first time that the conceptual homogeneity of the plan of Saint Gall has been put into question.

In 1952, and again in 1962,19 Hans Reinhardt expressed the view that the buildings which appear on the large rectangular tracts to the east and west of the church were not part of the original scheme, but an afterthought or a later addition. Reinhardt deduced this from certain technical observations about the physical composition of the plan which were made in 1949 when the parchment was detached from its post-mediaeval backing of linen. The plan, as is visible even on the greatly reduced photograph shown in Fig. 1, was not drawn on a

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11 That the plan of Saint Gall was drawn to a scale of 1/16" : 1' was first expressed by me in the French edition of the catalogue to the Council of Europe Exhibit Karl der Grosse: "Le plan est entièrement dessiné d’après une échelle, ou le 1/16e d’un pouce sur le parchemin représente un pied sur le terrain. Connu dans une relation d’unités égales, cela signifie 1:192 (1/16 x 12 = 192/16), rapport de grandeur qui approche l’échelle métrique du 1:200, mais qu’il ne faut aucunement confondre avec celle-ci; puisque la relation 1:200 n’existait pas dans le système métrique médiéval, où le pied était divisé en 12 pouces, et le pouce en seize seizièmes." See Charlemagne, Aix-La-Chapelle, ouvre, rayonnement et survivances, Brauneiis, ed., 399.

12 I am delighted to find that in an article that became available to me only after the present study was completed, Konrad Hecht had independently come to the same conclusion: "Der Maßstab 1:200 ist für einen mittelalterlichen Plan zwar plausibel, aber doch irreg, denn dieser Maßstab setzt die dezimale Teilung der Fussmassen voraus ... Der St. Galler Plan wurde nicht im Maßstab 1:200, sondern im Maßstab 1/16" : 1' entsprechend 1:192 gezeichnet." See Hecht, "Schema oder Bauplan?" 166-206, esp. pp. 187f.

13 For a brief résumé of the adoption of the metric system see Arthur E. Kennelly, Vestiges of Pre-metric Weights and Measures, New York, 1928, 12-27; for a comprehensive and detailed account of the establishment and propagation of the metric system and the operations which determined the meter and the kilogram, see Adrien Favre, Les origines du système métrique, Paris, 1931, and G. Bigourd, Le système métrique des poids et mesures, Paris, 1903.

14 Ibid., 105f.

15 Ibid., 106f.

16 Ibid., 105f.

17 Ibid., 106: "Überraschenderweise ergeben sich in keinem der Hauptmassen Teile des Karolingischen Fusses von 34.0cm." Ibid., 106f.; "Völlig unerwartet enthielt die maschinelle Untersuchung des Plans, dass er sich aus heterogenen Teilen zusammen setzt. Das aber bedeutet wohl nichts anderes, als dass diese Teilkomplexe aus verschiedenen Quellen stammen und kompiliert worden sind." 19 Reinhards, Der St. Galler Klosterplan, 8, and same author, "Bemerkungen zum Klosterplan und zur Studienuntung," 59.

20 Konrad Hecht, "Schema oder Bauplan?" 166f., expressed the view that all five sheets were sewn together before the drawing was started. He doubts that the draftsman could have fitted the corresponding portions of the drawing together so
single sheet of parchment, but on five separate pieces of calf-
skin sewn together (Fig. 7). An analysis of the overlapping
margins of these sheets discloses that the drawing was made
in three successive stages: first, the center portion of the
monastery with the church and the claustral structures, as well
as the buildings which are grouped immediately around the
church, viz. to the north: the house for distinguished guests,
the so-called outer school and the abbot's house; to the south:
the hospice for pilgrims and paupers, the stable for horses and
oxen, the workshops of the coopers and turners, the monks'
bake and brew house, their mill, mortar and drying kiln, the
house for the workmen and the large monastic granary. All
of these buildings were traced on sheets 1, 2 and 3, which must
have been sewn together before the draftsman started his
work. This can be inferred from the fact that wherever a line
runs across any one of the seams of this group of sheets, it
does so in a continuous motion. The buildings to the east
and west of the church were separately traced on sheets 4 and 5
which were attached to sheet-group 1-2-3 after the drawing
on the latter had been completed. This must be inferred from
the fact that the overlapping margins of sheets 4 and 5 cover
up a portion of the drawing, and even the writing, of the
center group of sheets (sheets 1, 2 and 3).20 Reinhardt's
factual observations on this point are correct and important,
but to infer from them that the scheme of the plan was not
the product of a single creative act21 involves a confusion be-
tween the conceptual homogeneity of the original and suc-
cessive stages of the physical execution of the copy. How
could a monastery function without the buildings which
appear on the top and the bottom sheet of the plan—such
basic and indispensable monastic facilities as the novitiate,
the monks' infirmary, the cemetery, the house of the physi-
cians, the house for bloodletting, the vegetable garden and the
gardener's house, the houses for the chicken and geese and
their keepers as well as the entire aggregate of buildings west
of the church which shelter the milk and cheese producing
animals so vital to the monastic economy? An analysis of the
distribution of the buildings and their respective functions in
the monastic comity discloses that there is no conceptual
disparity along the lines which Reinhardt suggests. Some of
the most vital claustral needs are met by installations which
lie in the eastern tract of the monastery (novitiate and all of
the medical services), whereas some of the most basic service
functions (storage, milling, crushing and drying of grain, all
of the crafts and labors, stabiling of horses and oxen) are
accommodated in houses which are huddled around the monks'
cloister on the center group of sheets (sheets 1, 2 and 3).

Reinhardt's views of the composite genesis of the plan were
accepted in 1957 and 1962 by Erwin Poeschel,22 who believed
them to be corroborated by the fact that the author of the plan
of Saint Gall, in his famous letter of transmission (written
upon the upper margin of the plan) refers to the monastic
buildings as officinae, i.e. 'workshops.'23 This, Poeschel
argued, can only mean that the layout of the church and the
cloister had already been worked out in a previous drawing
and that the plan of Saint Gall was primarily concerned with
the development of the service structures. It would have been
historically sounder to infer from the use of the word officina
that the author of the note employed this term in the general
sense of "building" or "installation" rather than taking the
radical step of concluding from its occurrence that the plan was
patched together in separate conceptual stages. A closer look
at the use of the word officina in mediaeval literature proved
subsequently, indeed, beyond any shadow of doubt, that the
word was employed in this broader sense—not only in the
monastic nomenclature of the ninth century, but even in the
language of the very founder of Western monasticism, St.
Benedict.24 "The workshops wherein we shall diligently exe-
cute all these tasks," we are told in Chapter 4 of the Rule, "are
the enclosures (clastra) of the monastery and stability of the
congregation,"25 to which the ninth century commentators
Basilius and Pseudo-Paulus add: "and properly does he [St.
Benedict] refer to these workshops in the plural form, because
the places in the monastery where the 'work of God' is done

20 Reinhardt, loc. cit.: "Aus diesen Feststellungen geht eindeutig hervor, dass un
sprünglich nur die mittlere Partie des Klosterplans mit Kirche und Klausur
bestand und dass die Zeichnung erst später vergrössert worden ist." 21 Erwin Poeschel, "Um den Karolingischen Klosterplan in St. Gallen," in Neue
Zürcher Zeitung, September 29, 1967, and same author "Bericht über die Stu
lexi. The proper translation of this is: "For thee, my sweetest son Coecurb[2]
us, have I made this copy of the arranging of the monastic buildings." 23 See Bischof, "Die Entstehung des Klosterplanes in paligraphischer Sicht," 67f.
and Hafner, "Hildems Regelnkommentar," 179f.
24 Officina auro, ubi haeo omnia diligenter operamur, claustra sunt monasterii et
stuaullis in congregatione (Benedicti Regula 4.79, Hanslik, ed., 50) and Rule of
Saint Benedict, McCann, ed., 32f.
are many; one workshop is the place where the Holy Scriptures are read, another one is the place for prayer, another one the place where the sick are attended to, and still another one the place where the dead are buried."

The commentary leaves no room for misinterpretation: "workshop" is a term that applies to the church as well as to all of the clausal structures. It is applicable even to "the place where the dead are buried."

Reine's attempt to question the conceptual homogeneity of the plan of Saint Gall is no less convincing than those of Reinhardt and Poeschel. It is also no less distressing. Like them it violates, on flimsy grounds, the very spirit of the historical forces which produced the plan.

Recent studies have made it clear that the scheme for a monastic settlement known to us through the plan of Saint Gall was a statement of policy drawn up at the highest levels of political and ecclesiastical administration during two meetings held at the palace of Aachen, in the summer and autumn of the years 816 and 817.27 The primary goal of these two synods was to establish guiding standards for the spiritual and temporal conduct of monastic life.28 The scheme embodied in the plan of Saint Gall aimed in the same manner at the establishment of guiding standards that could be followed in the layout of the physical shell of a monastic settlement. Its purpose was to settle, once and for all, the important question of the number and function of the buildings of an ideal monastic settlement, their respective order and their relative dimensions. Like the reform movement itself, the scheme of this plan was the embodiment of the overriding preoccupation of the period to establish unity (unitas) where life had been controlled by disparate traditions (diversitas), to put a single rule (una regula, una consuetudo) in the place of the mixed tradition (regula mixta).29

It is a historical incongruity to propose that a document conceived in this spirit would have been patched together from fragments drawn in disparate scales, thus perpetuating in its technical execution the very disorder which it strove to overcome on a conceptual level.

The two synods of Aachen did not deal in a specific sense with the needs for uniformity of scale and measures. Yet chronologically, the Carolingian battle for standardized weights and measures even antedates the monastic reform. The capitularies of Charlemagne abound with directives promulgated for the purpose of establishing unity where diversity prevailed. In his admonitio generalis, issued on March 23, 789, the emperor rules "that everybody shall make use of the same and correct measures and of just and equal weights, in the towns as well as in the monasteries, whether selling or buying."29 The capitulary of Frankfurt, issued in June, 794, speaks of a "recently established royal bushel" (modium publicum et noviter statutum)31 and from the celebrated book of instructions to the managers of royal estates, the Capitulare de Villis, we learn that standard molds for such measures of capacity were kept in the royal palace.32 Again in 802 Charlemagne entreats his missi to see to it that "just and uniform measures" are employed throughout the empire.33 It was in the pursuit of the same drive toward uniform standards that the emperor dispatched special messengers to Monte Cassino for the purpose of finding the precise weight of the pound of bread (libra panis) and the measure of wine (hemina) which St. Benedict had assigned to the monks as their daily allowance.34 The insistence with which the capitularies reiterate the need for uniformity of weights and measures bears witness to his profound preoccupation with binding rules in such matters. Directives to maintain established standards and severe warnings against their adulteration were reissued by Charle-
magne in 806, and 813, and by Louis the Pious in 820, 829, 844, 847, and 847.

It is true that practically all of the measures specifically mentioned in these ordinances are measures of weight and capacity: the "peck" (modius), the "sixteenth part of a peck" (sextarius), the "bucket" (situla) and the "basket" (corbus). These measures are essential for barter and trade, which formed the basis for the entire Carolingian economy. They would be the first to be singled out, if a general principle were to be illustrated by specific examples. But it would be absurd to presume that measures of length were not an implicit part of these directives. The drive for uniformity was programmatic and universal. It pervaded the whole of the political, administrative, economic and spiritual life of the Carolingian era, both under Charlemagne and Louis the Pious. On the highest level the aim was the "unity of the empire." A precondition of the unitas regni was the "unity of the church." The unitas ecclesiae, in turn, depends on uniform standards of conduct (una consuetudo) both for the secular clergy and for the monks.Blueprints for this unity (forma unitatis) were the directives for canons and canonsesses which were framed in the synod of 816 and the rules controlling monastic life which were issued at this same council and at the synod of 817. The importance of these events for the whole of the state was underscored not only by the fact that these directives emerged from assemblies which were held in the royal palace of Aachen but also that they were subsequently promulgated by the emperor himself in the form of official capitularies and thus acquired the character of public laws.

Surely enough, no truly binding unity might ever have been attained in all of these segments of life and on all of the levels. But to propose—as Reine's theory of the multiplicity of scales in the plan of Saint Gall implies—that a blatant violation of these concepts of unity would have been perpetrated in a document of paradigmatic significance, drawn up in the palace itself under the eyes of the country's leading bishops and abbots, appears to me to be an incongruous historical assumption.

It is an incongruous assumption even on simple visual grounds. In his reliance on precision instruments and modern slide rules Reine has neglected a powerful tool of visual analysis: the naked human eye. For to the naked eye the consummate conceptual and technical homogeneity of the plan reveals itself with infinitely greater strength than could be disclosed by any mechanical devices. The order in which the buildings are arranged is immaculate throughout the entire width and length of the plan. Since the plan is traced without the aid of a straight-edge or the benefit of a compass, it is full of minor irregularities. Yet despite these shortcomings—inevitable in a freehand tracing, and especially one of such bulky dimensions—one cannot fail to observe that each building was developed within the boundaries of a superordinate building site in careful alignment with its companion structures and that the aggregate of these larger building sites forms a mosaic of perfect order and rationality. This order is tight and consistent. It does not show, at any place, the kind of break or formal incompatibility which one associates with an architectural composition pieced together from heterogeneous parts.

Reine, in advancing his new interpretations of the axial explanatory title of the church, laid emphasis on the fact that he did so without reference to the views of students who had dealt with this problem in earlier studies: "Wenn ich im Folgenden eine Reihe von neuen Gedanken zum St. Galler Klosterplan äussere, so beruht das auf der Methode, einmal alles bisher über den Plan publizirte ... gleichsam zu verges...
sen oder nicht nachzuschlagen und sich mit dem Dokument naiv zu befassen als wäre es ein Neufund.\textsuperscript{47}

This procedure appears to me to be another grave methodological deficiency in Reinle’s approach. Whether or not a new hypothesis is a preferable alternative to an earlier one can be established only by a careful comparison of the merits of the new conjecture with those of the older. In depriving himself of this precautionary measure, Reinle jettisoned one of the fundamental safeguards of historical investigation.

A careful analysis of the existing theories on the dimensional inconsistencies of the plan of Saint Gall would have shown that there is no need for the creation of a new one, since two of the earlier studies had already settled this problem in a manner superior to the one proposed by Reinle. In an article published in 1948, Otto Doppelfeld\textsuperscript{48} advanced the theory that all of the dimensional inconsistencies of the explanatory titles of the plan could be resolved if one were to assume that the existing parchment was not an original, but a copy and that in the process of copying the monk who wrote the titles inadvertently converted the figure 300 of the original (in Latin, CCC) into 200 (in Latin, CC) by simply omitting one of the Cs of the Latin numeral. Through another scribal error, namely the simple substitution of the letter d for an s in the explanatory title which defines the interstices of the arcades of the church (No. 4), he ended up with the disturbing figure “twelve” (\textit{bis senos}, i.e., “twice six”) where the original read twenty (\textit{bis denos}, i.e., “twice ten”). This explanation was reiterated in 1956 by Wilhelm Rave\textsuperscript{49} and had, in fact, already been expressed in 1930, in an unpublished manuscript of Erwin Panofsky’s.\textsuperscript{50} The idea was brilliant in conception and appeared to be even more engaging when subsequently it was proved, beyond any shadow of doubt, that the plan was indeed not an original but a copy made by the process of tracing.\textsuperscript{51}

Yet even before this was established, Doppelfeld’s theory of scribal errors had already been challenged by a more convincing one, when Walter Boeckelmann, in 1956,\textsuperscript{52} advanced the view that the incompatibility of the drawing and the explanatory titles (as well as that of the explanatory titles themselves) was not the result of the operations of an erring scribe, but the reflection of a conflict that had arisen at the two synods of Aachen\textsuperscript{53} between the bold dimensional thinking of the old ecclesiastical leaders who shaped the policy of the church under Charlemagne and the more restrictive views of the leaders of the reform party who controlled the church under Louis the Pious.

The dimensions listed in the explanatory titles, so Boeckelmann contended, were not meant to explain the drawing, but to correct it. And since the proponents of these corrective measures did not take it upon themselves to revise the drawing in the suggested sense, “the disagreement was not solved in the plan; the conflict remained preserved.”\textsuperscript{54}

Prior to Boeckelmann the students of the plan of Saint Gall were divided into two schools of opposing and incompatible views. One group was willing to give credence to the drawing and distrusted the conflicting explanatory titles;\textsuperscript{55} the other proposed that the true intent of the draftsman was expressed in the dimensions listed in the explanatory titles and that the drawing could only be understood as a schematic form of rendering.\textsuperscript{56} Boeckelmann reconciled these two conflicting views by demonstrating that the conflict between the drawing and the explanatory titles was an expression of a change of thinking of the leaders of the Church that occurred between the time of the creation of the original scheme and its formal adoption.

In contrast to those who held that the plan of Saint Gall was purely a schematic rendering, Boeckelmann believed that it was drawn to a definite scale and that the key to this scale was to be found in the forty feet which the draftsman ascribed to the width of the nave of the church. He observed that values consistent with this scale can be recognized in the dimensions of many other areas of the plan. The cloister yard, for example, if measured in the light of the 4-foot width of the nave, forms

\textsuperscript{47} Reinle, “St. Galler Klosterplan,” 91.

\textsuperscript{48} Doppelfeld, “Der alte Dom zu Köln,” 1-32.

\textsuperscript{49} Rave, “Gedanken über den St. Gallener Klosterplan,” 46f.

\textsuperscript{50} Erwin Panofsky, “Zum Problem des St. Gallener Kirchengrundrisses,” unpublished manuscript, p. 5.

\textsuperscript{51} Horn, “The Plan of St. Gall—Original or Copy?,” 79-102; and Bernhard Bischof, “Die Entstehung des Klosterplanes,” 67-70.

\textsuperscript{52} Boeckelmann, “Der Widerspruch im St. Galler Klosterplan,” 125-234.

\textsuperscript{53} Ibid., 126ff.

\textsuperscript{54} Ibid., 126ff.

\textsuperscript{55} To this group belong the following scholars: Wilhelm Effmann, Friedrich Osten- dorf, Ernst Gall, Edgar Lehmann, Otto Doppelfeld, and Wilhelm Rave. See the following studies: Wilhelm Effmann, \textit{Die karolingisch-ottonischen Bauten zu Wer-

\textsuperscript{den}, 1, Strasbourg, 1899, pl. 62, fig. 44) Friedrich Ostendorf, \textit{Die deutsche Baukunst im Mittelalter: Aufnahme und Differenzierung der Bauformen}, Berlin, 1923, 43 n. 262; Gall, \textit{Karolingische und ottonische Kirchen}, 16, pl. 1, fig. 4; Lehmann, \textit{Der frühe deutsche Kirchenbau}, 136, fig. 93; Doppelfeld, “Der alte Dom zu Köln,” 1-12; Wilhelm Rave, “Gedanken über den St. Gallener Klosterplan,” 46f.

\textsuperscript{56} The adherents of this view include Georg Dehio, Joseph Hecht, Wilhelm Pinder and Hans Reinhart. The first modified drawing of the plan was published by Dehio and Von Bezdol, \textit{Die kirchliche Baukunst}, pl. 1, pl. 42, fig. 2. The same drawing is reproduced in all editions of Dehio’s \textit{Geschichte der deutschen Kunst}, see 1st ed., 1, 1919, 25, fig. 37. See also Hecht, \textit{Die romanischen Kirchen des Bodenregister}, 1, 27ff., pl. 8, fig. a; Wilhelm Pinder, \textit{Die Kunst der deutschen Kaiserzeit bis zum Ende der staufischen Epoche}, Leipzig, 1937, 68, fig. 4; Reinhart, \textit{Le plan carolingien de Saint-Gall,” 270ff. and overlay of p. 272; same author, Der
1. Plan of Saint Gall (detail), church and claustrum (ca. ½ of size of original)
2. Plan of Saint Gall (detail), eastern part of church (size of original)
3. Plan of Saint Gall, monks' refectory (size of original)

4. Plan of Saint Gall, house for distinguished guests (size of original)
5. Plan of Saint Gall, monastery church, perspective view of interior, looking east, reconstruction

7. Plan of Saint Gall, monastery church, plan (redrawn by E. Born)
8. Plan of Saint Gall, monastery church, transverse section, reconstruction

9. Plan of Saint Gall, monastery church, longitudinal section, reconstruction
10. Diagram showing how the parchment upon which the Plan of Saint Gall is traced was pieced together from five separate sheets of calf-skin. Nos. 1, 2 and 3 were sewn together before the tracing was started. Nos. 4 and 5 were separately traced, and then attached to the center group of sheets (1, 2, and 3) from above.
11. Plan of Saint Gall, monastery church, southern transept arm with 2\(\frac{1}{2}\) foot module superimposed upon facsimile red print (size of original)
13. Plan of Saint Gall, church and *claustrum* with 40 foot module superimposed upon facsimile red print (¼ of scale of original)

grid squares are 40 feet by 40 feet
14. Plan of Saint Gall, with 40 foot module superimposed upon entire monastery site (not in a fixed scale relation to original)
15. Plan of Saint Gall. Diagram showing how the scheme of the plan was developed from a mastergrid of 160 foot squares determining the axial location of the church and the layout of the cloister (not in a fixed scale relation to original)
a square of 100 feet; the rectangular area in its center, a square of 20 feet.57

Boeckelmann’s theory, in my opinion, was correct. It not only reconciled more of the conflicting traits of the plan than any previous hypotheses, but also placed them in their proper historical perspective. More recent investigations have shown that there indeed existed a serious ideological split at the synods of Aachen between an old conservative group and the leaders of the reform party.58

To reconstruct what the church of the plan would have looked like had it been modified in the light of the corrective titles is an intriguing historical task and has produced a variety of different proposals, both before and after the publication of Boeckelmann’s study. It is not surprising that no agreement has yet been reached in this matter. The attempt involved some delicate changes on which even Carolingian architects might not easily have agreed.

One of the most curious and historically most fascinating features of the church drawing is that it is constructed according to a system of squares (Fig. 13), exhibiting a principle of spatial organization that became a guiding feature in certain schools of the Romanesque two centuries later. To reduce the church to the requested length of 200 feet implies the abandonment of the square schematism; anyone who attempts to redraw the church using the measurements listed in the explanatory titles has made this distressing discovery. Not wishing to totally relinquish this feature in his modified drawing, Georg Dehio, who belonged to a generation of architectural historians profoundly interested in the problem of modular geometricity in mediaeval architecture, retained the squares in the transept and in the fore-choir. By diminishing the interstices of the arcades of the nave to the stipulated 12 feet, he then arrived at the compromise length of 218 feet (text fig. 3).59 Joseph Hecht, who followed similar lines of thinking, arrived at a length of 224 feet.60 Reinhardt, who tended to underrate the square schematism of the church,61 attempted to resolve these discrepancies by developing a drawing in which the length was actually reduced to the requested 200 feet (text fig. 4).62 But to attain this goal he found himself compelled to reduce the fore-choir and the space of the crypt beneath it to

Fig. 3. Plan of Saint Gall, monastery church, modified in the light of its explanatory titles by Georg Dehio

St. Galler Klosterplan 18ff. and figs. on pp. 21f.
59 Dehio, Die kirchliche Baukunst, pl. vol. 1, pl. 42, fig. 2.
60 Hecht, Die romanischen Kirchen des Bodenseeregimes, 1, 218; pl. 8.
61 Reinhardt, “Le plan carolingien de Saint-Gall,” 269: “A première vue, déjà, on reconnaît que, dans le dessin, le chœur ne forme pas un quadrilatère à côtés égaux, mais qu’il est nettement barlong. De même, on constate, a l’aide d’un compas, que les croisillons, à leur tour, n’atteignent pas le carré parfait.” On the basis of these observations, Reinhardt, Der St. Galler Klosterplan, 25, goes so far as to question the entire schematism of the church of the plan of Saint Gall: “Es ist bereits die Rede davon gewesen, dass in neuerer Zeit dem Klosterplan von St. Gallen eine in die Zukunft weisende Bedeutung zugemessen wurde, insofern in seinem Kirchensrundriss bereits die Quadratur massgeblich gewesen sei sowie sie erst zweihundert Jahre später in den deutschen Bauten des 12. Jahrhunderts ausgebildet wurde. Es ist oben gezeigt worden dass dies jedesfalls für den Plan von St. Gallen nicht zutrifft.”

Similar views had already been expressed by Samuel Guyer in 1945 (“Beiträge zur Frage nach dem Ursprung des kreuzförmigbasilichen Kirchenbaus des Abendlandes,” Zeitschrift für Schweizerische Archäologie und Kunstgeschichte, 7, 1945, 98, 100), but were convincingly refuted by A. Knoop in a drawing which shows a grid of 10-foot squares superimposed upon the plan of the church (“Die Probstskirche Wagenhausen,” ibid., 9, 1952, 207, fig. 11; and Kunstgeschichte des Bodenseeraumes, 213ff.).
62 Reinhardt, “Le plan carolingien de Saint-Gall,” 273; also Der St. Galler Klosterplan, 18, figs. on pp. 21f.
Fig. 4. Plan of Saint Gall, monastery church, modified in the light of its explanatory titles by Hans Reinhardt
Fig. 5. Plan of Saint Gall, monastery church; perspective view of fore-choir, crypt and apse as reconstructed by Hans Reinhardt

one-fourth of their original dimensions, and thus he arrived at a modified plan which retained no spiritual kinship whatsoever to the original concept of the drawing.

Reinhardt contracts the church most severely where contraction hurts most: in the all important area around the high altar and the tomb of St. Gall, where the entire body of the monks assembles daily for a total of four hours or more in common chant and the celebration of the divine services. He placed the high altar against the very edge of the raised choir, where it drops vertically down to the floor level of the transept leaving no space for the officiating priest and his attendants (text fig. 5). A step on the eastern side of the altar suggests that Reinhardt imagines the priest standing behind the altar, facing west. This not only is incompatible with what is known to have been a general custom in Carolingian liturgy, but also is in flagrant conflict with fourteen other altars in the church of the plan (Figs. 1, 2), whose location leaves no doubt that the officiating priest stood west of the altar, facing east: the location of the altar barriers and the position of the crosses leave no doubt on this score.

One feels equally disturbed about Reinhardt’s modification of the crypt. The draper of the plan provided the monastery with two crypts with different but complementary functions (Fig. 2). One of these is a circumambient corridor crypt (Inuolatio arcuum), in the shape of an inverted U, which takes the pilgrims and other secular visitors to the tomb of St. Gall. The entrances to this corridor crypt are marked In cripta Ingressus t egressus (southern transept arm) and In cripta Introitus t exitus (northern transept arm). They are reached by passageways that cut across the transept arms and are separated by screen partitions from the contiguous areas, which are reserved for the exclusive use of the monks, in the body of the transept. The second crypt lies under the fore-choir and is reached from the crossing through a passage, marked accessus ad confessionem, between the two flights of steps that lead up to the fore-choir. This can only have been a hall crypt providing the monks with prayer space around the tomb of St. Gall. Reinhardt eliminates this confessio altogether and thus creates a spatial vacuum in one of the spiritually most vital spots of the church.

From a liturgical and functional point of view the removal of the fore-choir is fatal. Moreover, it is devastating in its effect on the subsidiary spaces of the sacristy and the scriptorium, which are built against the fore-choir and, like the latter, each cover a surface area of 40 by 40 feet. What does Reinhardt propose to do with them? To reduce them proportionately would render them unusable;4 to retain them as originally planned would amount to an aesthetic degradation of the apse which is incompatible with its liturgical and architectural function.

Reinhardt’s proposal is undesirable even in general historical terms. The interposition of a separate spatial unit between apse and transept is one of the new and original features of Carolingian architecture. It appeared in Neustadt-on-the-Main shortly after 768–769; in the abbey church of Saint-Riquier (Centula) between 790–799; in the church of Vreden around 800; in the monastery of Saint Mary and Saint Peter (later the cathedral church of Cologne) prior to the death of its founder, archbishop Hildebold, in 806; in Saint Mary at Mittelzell on Reichenauf, as rebuilt by abbot Haito between 806 and 816; and in the abbey church of Hersfeld, if Grossmann’s reconstruction is correct, between 831 and 851.6 The primary motivation for this new spatial entity was, as Thümmel has correctly pointed out, the desire to isolate and strengthen the importance of the high altar, at which the choral services were

63 On altar orientation in Carolingian times see Joseph Braun, Der christliche Alter, 1, Munich, 1924, 42ff.
64 Previously correctly observed by Bockelmann, “Der Widerspruch im St. Galler Klosterplan,” 127: “Sakristei, Schreibtube und Bibliothek schrumpfen zu schmalen Kammern zusammen . . . der Korrigierte Plan kann nicht mehr als exemplarisch gelten.”
65 For Neustadt-on-Main see Walter Bockelmann, “Das Karolingische Münster zu Neustadt am Main und sein quadratisches Schema,” in Die Jubiläumsreden der Koldewey-Gesellschaft in Stuttgart, 1995, 43–45, and “Gewöhnungen im Früh-
held, and to provide more space for the officiating clergy. The increasing dimensions of the crypt, and the latter’s division into an outer corridor crypt for the pilgrims and an inner confessio for the monks, is directly related to this development. Both of these innovations were responses to pressing liturgical needs.

It is easy to understand why Dehio was reluctant to undertake any changes in the eastern parts of the church and took the step, for which he was subsequently so severely criticized, of making the church a little larger (218 feet) than the stipulated 200 feet. However, there remains the question whether Dehio is really guilty of such a compromise. His reconstruction may in fact be based upon a more accurate interpretation of the title which prescribes the reduction. Dehio’s critics interpret the propositional phrase AB ORIENTE AD OCCIDENTE to mean “from the apex of the eastern apse to the apex of the western apse.” There is no assurance whatsoever that this is in fact what the title meant to convey. The first five letters of the phrase, AB ORI, are inscribed into the eastern apse, which means that this apse was a component part of the designated length. But the inscription does not run into the round portion of the western apse; it stops in the westernmost bay of the nave with the numeral ‘CC. Literally interpreted this would mean that the western apse was not meant to be included in the designated length of 200 feet. If it was not, then Dehio’s reconstruction (text fig. 3) would run only 8 feet beyond the stipulated length (nine arcades of a span of 12 feet = 108 feet; crossing unit = 40 feet; fore-choir = 40 feet; apse = 20 feet. Total = 208 feet)—close enough to be acceptable; and acceptable without any shadow of doubt, if the radius of the eastern apse were shortened from 20 feet to 12 feet.

By far the most radical attempt of reconciling the drawing of the church of the plan of Saint Gall with that of its corrective explanatory titles was that which Wolfgang Schöne published in 1960. Schöne not only shortened the church to the desired 200 feet, but applied the same reduction to all the other buildings of the plan. In advancing this theory he either overlooked or disregarded the fact that the same proposition had already been discussed and convincingly rejected twenty-two years earlier in Fritz Viktor Arens’ excellent thesis, Das Werkmass in der Baukunst des Mittelalters. Arens pointed out that if one were to redraw the plan of Saint Gall according to the measurements given for the length of the church (i.e., 200 feet), the cloister and all of the service structures of the plan would be too small to perform their designated functions. He observed that the dimensions of the beds in the monks’ dormitory make perfect sense, if interpreted in the light of the 40-foot width of the nave of the church (2½ feet wide, 7½ feet long), but become unrealistic if related to the 200 feet stipulated for the length of the church (1½ feet wide and 5 feet long). His is the most rigorous argument in favor of the assumption that if any of the measurements given in the explanatory titles of the plan reflect the original scale, it is the 40-foot figure listed for the width of the nave of the church.

My own analysis of the plan confirms this view. If the entire plan were redrawn in the light of the title which assigns to the church a length of 200 feet, not only would the monks, including the abbot and the visiting noblemen (i.e., monks’ dormitory, abbot’s house, and house for distinguished guests) no longer fit into their beds, but the refectory would be too small to seat the full contingent of monks, the horses would lack the required floor space to stand in their stables, and the workmen could not carry out their respective crafts and labors.

The most decisive counter-argument, however, to Schöne’s interpretation of the plan is to be found in a statement by a man who lived at the time when the plan was drawn. In his commentary on the Rule of St. Benedict written around 845 in the monastery of Civate, Italy, Hildemar, a monk from Corbie, made some illuminating remarks about the size of the buildings in which the monks are housed (claustra monasterii): They should not be so small that a monk wanting to do some chore finds cause for murmur because of restricted space, nor should it be so grand that it would invite him to spend his time with someone else in idle gossip. In a subsequent paragraph he adds this important piece of information: It is generally held that the cloister should be 100 feet square and not less because that would make it too small; if however one should wish to make it larger, this is permissible. The plan of Saint Gall complied with this rule. Its cloister yard measures 100 feet by 102½ feet. Schöne reduces it to a little less than 67 feet by 67 feet. It is historically incongruous to assume that a scheme of paradigmatic significance worked out in an assembly of leading bishops and abbots of the empire, should propose a cloister whose dimensions fall by

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67 Throughout the entire width and length of the plan the scribe takes the utmost care in placing his titles so that they exactly correspond to the area which they describe. Among the total of 340 separate entries there is not a single one where this relationship would be ambiguous or susceptible to misinterpretation.
69 Arens, Das Werkmass, 66f.
70 Arens, loc. cit.; cf. my analysis of the dormitory below, p. 298, Fig. 12.
71 I shall be dealing in greater detail with this point in my forthcoming book on the plan of Saint Gall.
72 Wolfgang Hafner has drawn attention to this fact in his interesting article, “Hildemars Regelkommentar,” 177-92.
73 Clairstra monasterii . . . Nec debet esse late pars, ut cum aliquis volu operari monachus, occasione interitter murmurandis propert pareisatem, nec ita debet
The reconstruction of Adolf Reinle (text fig. 6), because of his radically different interpretation of the axial explanatory title of the church, was bound to occupy a position entirely apart from those of any of the previous students of the plan. Translating the axial title of the church AB ORIENTE AD OCCIDENTE[M] PED 'C' in the sense of “THIS PLAN IS DRAWN AT THE SCALE OF 1:200,” he finds himself under no compulsion to reduce the church to a length of 200 feet, as so many of the others had done. He endows it with its full length of 300 feet. However, in adjustment to the title which designates the intercolumnar interstices of the arcades of the nave to 12 feet, he feels himself induced to increase the number of the arcades from nine (as shown in the original) to fifteen (as shown in his reconstruction). Reinle draws support for this interpretation from the observation that arcades of a span of 20 feet (6.8m) are not known to have existed in any of the large colonnaded basilicas of the first millennium. This being as it is, he concludes “we must assume that the columnar order of the church of the plan of Saint Gall is rendered in a schematic manner in logical explication of the system of squares which controls the groundplan of the church.” He categorically rejects any kinship between this geometricity and the square schematism of the Romanesque.

This is too simple a way, in my opinion, to explain a difficult historical phenomenon. Columnar interstices of 20 feet, it is true, are not known for the period in which the plan was drawn. But this does not mean that such a solution was not within the grasp of an imaginative Carolingian architect. There is no reason to presume that the instruction to make the columnar interstices 12 feet wide stemmed from fears that arcades spanning twenty feet would be a constructional hazard. The shortening of the span might simply have been the inevitable corollary of the stipulated reduction of the length of the church.

The latter alternative appears to me more reasonable for two reasons:
1. the plan is not as “schematic” as Reinle would make it to be, and
2. in constructional terms a 20-foot span is entirely feasible.

The Plan is “schematic” in the sense that all of the monastery’s buildings are inscribed into a site of perfect regularity; it is an oblong whose sides correspond to the proportion 3:4. Again, it is “schematic” in the sense that this oblong is divided into subordinate sites of comparable regularity within which the houses are rigidly aligned as in the layout of the insulae of a Roman city—conditions, of course, which in actual construction would have to be modified in adjustment to the topographical peculiarities of a given site.

But the plan is not “schematic” in the sense that any of the practical requirements of the buildings had to be sacrificed in a width of 12½ feet, except for the one which is contiguous with the church and has a width of 15 feet to give a larger margin of space for daily chapter assemblies, which are held in this wing. This accounts for the overall dimensions 100 feet by 102½ feet, rather than the customary 100 feet by 100 feet. Cf. below, p. 306.

76 Reinle, loc. cit.
77 Ibid.
78 Ibid.
79 Cf. below p. 303.

Fig. 6. Plan of Saint Gall, monastery church, modified in the light of its explanatory titles by Adolf Reinle

| 74 Dicunt multi, quia claustra monasterii centum pedes debet habere in omni parte, minus non, quia parva est; si autem velis plus, potest fieri. Cf. Hafner, "Hildemars Regellkommentar," 180 n. 18; and Vita et Regula, Mittermüller, ed., 183.
| 75 The dimensions of the cloister yard are 75 feet by 75 feet. The cloister walks have no compulsion to reduce the church to a length of 200 feet, as so many of the others had done. He endows it with its full length of 300 feet. However, in adjustment to the title which designates the intercolumnar interstices of the arcades of the nave to 12 feet, he feels himself induced to increase the number of the arcades from nine (as shown in the original) to fifteen (as shown in his reconstruction). Reinle draws support for this interpretation from the observation that arcades of a span of 20 feet (6.8m) are not known to have existed in any of the large colonnaded basilicas of the first millennium. This being as it is, he concludes "we must assume that the columnar order of the church of the plan of Saint Gall is rendered in a schematic manner in logical explication of the system of squares which controls the groundplan of the church." He categorically rejects any kinship between this geometricity and the square schematism of the Romanesque.

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76 Reinle, loc. cit.
77 Ibid.
78 Ibid.
79 Cf. below p. 303.
order to conform to overriding standards of modular geometricity. Indeed, one of its most remarkable features is that despite its modular schematism the dimensions of its houses and rooms are designed with an acute awareness of the space needed to carry out their designated functions. In the copious literature on the plan of Saint Gall this fact has never been observed, yet detailed analysis shows that wherever a building served a practical function, its dimensions were calculated to guarantee that its particular purpose could be fulfilled adequately. In many instances the space allowed is slightly larger than required, but never is it in blatant excess of what was needed. I shall substantiate this point with a few examples.

A count of the beds of the monks and the various monastic officials discloses that the monastery was designed to accommodate between 100 and 110 permanent and 6 visiting monks. The dormitory of the monks is equipped with seventy-seven beds, the dormitory of the abbot’s house with eight. There are five beds in the porter’s lodging, two in the lodging of the master of the outer school. To this must be added an estimated three beds in the apartment of the master of the hospice for pilgrims and paupers, and a like amount in the house of the gardener. It is not quite clear from the plan where the chamberlain slept. There were at least two physicians, who may also have been monks. And a few of the regular monks must have lived with the novices in the novitiate. This brings the total of the religiosi to around 110.

There is no doubt in my mind that the architect who developed the scheme of the monastery based his work upon a clearly formulated population plan and adhered to this program with punctilious care as he worked out the dimensions of the respective buildings. There are two places in which his working procedure can be checked, the refectory and the church. In both these buildings, it had to be possible for all of the monks (with the exception, perhaps, of the few who were in charge of the novices) to assemble at the same time. In both places the seating arrangement is worked out to allow room for all the brothers, leaving some extra seats for visitors.

To begin with the refectory (Fig. 3): if we assume that each monk required a sitting area 2 1/2 feet wide (this is what he would need today and what we can safely expect him to have needed in the Middle Ages), the table of the abbot was capable of seating twenty-eight; the two L-shaped wall benches which run parallel to the abbot’s table, sixteen each; the two L-shaped wall benches in the western half of the building, each nineteen; and the two benches of the corresponding center table, twenty-two. Grand total: 126.

The refectory, accordingly, can accommodate all of the 100–110 brothers in a single sitting and allow, in addition, for a surplus of 16 seats to take care of an unexpected fluctuation, as well as the normal increase during the great religious festivals of Christmas, Pentecost and Easter when the novices were permitted to join their elders. There is also a table for visiting monks with a bench capable of seating six; this corresponds exactly to the number of beds that are shown in the lodging for the visiting monks. If the length of the refectory were reduced to 67 feet, as Schöne suggests, this building could not have accommodated the monks in a single sitting.

The same realistic awareness of spatial needs is disclosed in the layout of the benches in the church on which the monks are seated during the divine services (Fig. 2). The long L-shaped bench in the apse and the fore-choir seats forty-eight monks; sixteen monks can be seated on the freestanding benches for specially trained singers in the crossing; eighteen on the wall benches of the southern transept arm; twenty on the wall benches of the northern transept arm; and five on each of the two freestanding benches of the transept arms. Total: 112.

An equally informative example of the draftsmen’s keen and consistent apprehension of the spatial realities involved may be found in the house for distinguished guests (Fig. 4). The number of horses that could be stabled in the northern aisle of this house (stabula caballarum) is identical with the number of noblemen that could be bedded in the rooms provided for them at the two narrow ends of the building (caminata cum lectis). And the number of toilet seats provided in the privy for the servants is identical with the number of beds that could be placed in the servants’ bedrooms (cubicula servitorum). The privy covers a surface area of 45 feet by 10 feet and is internally equipped with eighteen toilet seats, each 2 1/2 feet square (a realistic assessment!). Each of the two bedrooms covers a surface area of 30 feet by 12 1/2 feet, yielding sufficient space for a total of eighteen standard beds like those shown in the other buildings of the plan. The bedrooms of the noblemen with private toilet facilities are furnished with four beds at each end of the house. The two stables for their horses.

80 For a brief description of this project and its rationale see the exhibition catalogue Karl der Grosse, Werk und Wirkung, Brauneis, ed., 401-10; and Charlemagne, Aix-La-Chapelle, source, rayonnement et survivances, Brauneis, ed., 391-400.
81 With regard to the number of monks see above p. 298. For details on my estimate of the corresponding number of serfs I must refer to my forthcoming book on the plan of Saint Gall.
83 For Cologne cathedral see the following works by Otto Doppelfeld "Der alte Dom
under the northern aisle of the house, each with a surface area of 30 feet by 12½ feet, can accommodate four horses each, allowing in addition to the required standing space sufficient space for taking the horses in and out and for feeding them, yet not much more than was needed for that purpose.

The same exacting attention to spatial needs can be observed in the layout of the buildings that contain the kitchens, the baths, the baking and brewing facilities, the mills and the mortars—but most consciously of all in the layout of the monks’ dormitory (Fig. 12). This building is designed to accommodate seventy-seven beds. Its dimensions (85 feet by 40 feet) are calculated to perform this task to perfection. The beds are slightly larger than needed because they were calculated in multiples of a standard module of 2½ feet which is used throughout the entire width and length of the plan. The average dimensions of a standard bed today are 30 inches by 72 inches (2½ feet by 6 feet). The standard bed on the plan of Saint Gall measures 30 inches by 90 inches (2½ feet by 7½ feet). Working with 2½ foot modules, the designer had the choice between a bed that was 12 inches shorter (2½ feet by 5 feet) than was needed for a fully grown man (2½ feet by 6 feet), or one that was 18 inches longer (2½ feet by 7½ feet). In taking the more generous alternative he not only protected the monks from being crowded into beds where sleep would have been a torture, but also provided the builder with a margin of safety for the indispensable head and footboards.

The size of the beds reveals a principle that can be observed in many other areas of the plan. Wherever the real dimensions of a small object fell short of the standard module of 2½ feet, the designer rounded such objects off to the next higher module—never the lower one. This was his method of making sure that a building, when actually constructed, could really accommodate the appurtenances with which it was equipped. It was his method, also, of providing for a safety margin of space for the thickness of the masonry walls which on the plan itself were rendered as simple lines.

It is inconceivable, in my opinion, that an architect whose punctilious observance of spatial needs is reflected in the dimensioning of even the smallest detail throughout the entire width and length of the plan, should have reverted to a radically different method of rendering when he drew the church, and should have spaced the columns at a distance of 20 feet when in fact he meant them to be placed at intervals of 12 feet. A consistent interpretation of the dimensional layout of the plan permits for no other conclusion than the draftsman meant what he drew. What he had in mind were arcades cutting deep into the masonry of the nave walls (Fig. 5) with its supports so spaced as to give bodily expression to the square schematism on which the plan of the church is based. This schematism is a conscious and willed aesthetic principle. It is a concept fundamentally different from that which produced the low and narrowly spaced columnar orders of the early Christian basilicas of Rome. Contrary to what Reinle believes, it is an ingenious anticipation of the square schematism of the Romanesque.

Even in purely constructional terms arcades with a span of twenty feet are a perfectly feasible solution. The proof of this will be found in the drawings for a three-dimensional reconstruction of the church (Figs. 8–10) which Ernest Born and I worked out in preparation of a model of the buildings of the plan of Saint Gall put on display in the Council of Europe Exhibit “Charlemagne” in Aachen, in the summer of 1965.80

The only issue on which I find myself in accord with Reinle—although for different and incompatible reasons—is that the church was drawn to a length of 300 feet. Neither Reinle, nor anyone else as far as I can see, has settled the question of why this should be so. What justified these extraordinary dimensions in a church serving a monastic community of probably not more than 260 people (around 110 monks, plus an estimated 150 serfs)?81 To find an answer to this problem we have to look at other Carolingian churches of comparable dimensions.

The church of the plan of Saint Gall is chronologically not the first, but probably the third or fourth, monastic church of this order of magnitude. The earliest was the abbey church of Fulda, in the form which it obtained under Abbot Ratger between 802–817. It had a clear inner length of 98.00 meters (= 321 modern English feet).82 The second was probably, although not demonstrably so, the monastery church of Saint Peter’s and Saint Mary’s in Cologne, founded by Bishop Hildegold, 800–819, which measured from apse to apse internally 91.20 meters (= 300 Carolingian feet, calculated at 1 foot = 30.04cm).83 The third was the church of the plan of Saint

Gall, as rendered in the drawing (Fig. 1), prototype plan: 817; copy made for Abbot Gozbert of Saint Gall: between 820 and 830. The fourth was the abbey church of Hersfeld, built between 831 and 850. Together with its westwork, it measured 102.85 meters (= 339 modern English feet).

Abbot Ratger’s church at Fulda, which stands at the head of this group, was a T-shaped basilica with continuous transept. The particular of its design leave no doubt that it was modeled after the church of Old Saint Peter’s in Rome. Like the church of the prima aposta it had its clerestory walls supported by two rows of columns which were surmounted not by arches, but by a straight entablature; like Saint Peter’s it had the end of the transept arms separated from the principal body of the transeptal hall.

The ideological reasons for this emulation of the design and size of the great early Christian proto-basilica of Rome during the reign of Emperor Charlemagne have been brilliantly analyzed by Richard Krautheimer. It was an outgrowth of the general process of Romanization of the Frankish Church and the Frankish kingdom, which started with the anointing of Pepin and his sons by Pope Stephen II in 753, and culminated in the coronation of Charlemagne as emperor on Christmas Eve of the year 800. It marks the point at which European architecture turned away from its Near Eastern background and looked to the West for new prototypes. There are other reasons for the appearance in transalpine Europe of buildings of unprecedented dimensions: the rapidly increasing veneration of saints, resulting in a multiplication of altars, all asking for additional space, a papal ordinance directing that mass could be celebrated only once a day at the same altar, and the desire to accommodate in a single building a variety of cults, which in earlier monastic churches had been distributed over several churches. Yet this dimensional increase raised serious economic problems. Whatever the historical incentives for the building of churches of a magnitude of 300 feet and more may have been, there still remained the question whether a community of an average of one hundred to two hundred monks could afford to build and maintain such structures. Ratger, the Abbot of Fulda, answered yes. But his monks, who paid for his ambitions with their toil and sweat, were disturbed by his building program to the point of rebellion. In formal petition presented to the emperor they pleaded that the construction of these “luxurious and superfluous buildings” (aedificia immensa atque superflua) be brought to a halt or reduced to a normal measure, because it taxed the brethren beyond endurance, left no time for the lectio divina and threatened to exhaust the monastery’s economic resources. The petition was twice submitted at the court: a first time in 812 to Charlemagne in Ratger’s presence—without success, a second time to Louis the Pious, between the first and second synod of Aachen (816–817)—when the monks attained their goal. Ratger, their abbot, was deposed and his newly appointed successor Egil was admonished “to reduce his building activity to a normal measure.”

Overindulgence in costly building activities was not the only reason for Ratger’s fall, and by itself may not have brought it about. He was accused of other violations of sound monastic administration, but the incident shows that the construction of a church 300 feet long was by no means an easy matter for a monastic polity and could have disturbing consequences not only for its economic stability but also for its spiritual health.

The rebellion of the monks of Fulda against the building activities of their abbot is the strongest historical argument to be deduced in support of Boeckelmann’s theory that the explanatory title which stipulates a length of 200 feet for the church of the plan is the expression of a programmatic re- trenchment. It might have been directly related to the struggles of Fulda.

II
The Scale of the Plan

From the preceding review it follows that all of the so-called dimensional inconsistencies of the plan of Saint Gall are resolved if one assumes that the church, originally planned to be 300 feet long (with columnar interstices of 20 feet), was in a subsequent review reduced to 200 feet (with a concomitant reduction of its columnar interstices to 12 feet). The original concept is expressed in the drawing, the revisions in its explanatory titles (Nos. 1 and 5). The drawing itself was not revised.

The key to the scale of the plan is to be found in the three titles which define the width of the church as 40 feet (No. 2) and the width of each of its aisles as 20 feet (Nos. 3 and 4). They represent the scale at which the claustral buildings and all of the other houses of the plan were drawn. To interpret these other buildings in the light of the figures given in the

86 On the multiplication of altars and the increasing cult of the saints in the Franko-Carolingian era, see Joseph Braun, Der christliche Altar, 1, Munich, 1924, 367, where Braun also points out that the increasing length of churches has something to do with the accommodation in a single building of a variety of cults formerly distributed over several churches. On the latter point specifically see Edgar Lehmann, “Die entwicklungs geschichtliche Stellung der karolingischen Klosterkirche zwischen Kirchenfamilie und Kathedrale,” Kunsthistorik, 6, 1953, 30ff.
87 For an excellent recent analysis of these events, see Semmler, “Studien zum Supplex Libellus,” 266-98. The best and most recent edition of the Supplex Libellus is that of Joseph Semmler’s in Corpus consuetudinum monasticarum, I, 319-27.
89 Ratger was also accused of shortening the divine office, cancelling traditional religious feasts, shortening the time of probation for the novices or accepting
revisionary titles is impossible, because it would reduce them to a scale at which they could no longer perform their assigned functions. The question now arises: how was this 40-foot scale of the nave internally graduated and how was it related to the actual Carolingian foot?

In turning, at this juncture, to an account of my own conclusions on this subject, I should like to start with a word of caution. While I hold the view that the plan was drawn to a definite scale, and that this scale was applied consistently throughout the entire breadth and width of the scheme,90 I do not think anyone could expect to be able to determine without any shadow of doubt the precise dimensions of every building, or any piece of furniture, shown on this scheme. This is impossible for a number of reasons. The most important among these are that the plan is not an original but a copy, and that this copy was traced without the aid of any supporting instruments through the opaque body of large and rather unmanageable pieces of parchment, which had to be held against a light surface in order to acquire the requisite transparency.91 This was bound to introduce a multitude of minor inaccuracies and inconsistencies that are incompatible with the precision of draftsmanship required in the development of the original scheme.

Moreover, there is clear evidence, as I have demonstrated elsewhere,92 that in the process of tracing original and overlay changed their respective position, in several instances causing a substantial measure of distortion. This is noticeable especially in the alignment of the clausular structures with the church and in the distorted layout of the stables in the southwestern corner of the settlement.

Despite all these distortions, minor or major as they may be, the plan of Saint Gall retains enough of the precision of the prototype to permit the conclusion that the original was based on a consistent and carefully calculated scale and to allow us to reconstruct the basic graduations of this scale.

The primary reason why this problem has not been solved in the past is, I think, that most of the students who took an interest in this matter were continental Europeans raised on the metric system. Being myself raised in this system, I, too, could not avoid interpreting the scale of the plan—as I presume many others tried before me—by constructing a straight-edge on which the value forty (width of the nave) was graduated into forty equal units of one. Applying this scale to the various buildings of the plan as well as to the open spaces between them, I recognized quickly, yet not without consternation, that a staggering majority of the dimensions appeared to coincide with intermediate values that did not make sense in terms of an even numerical progression. I was puzzled by the frequent occurrence of such values as 21/2, 71/2, 121/2, 171/2, 221/2, 271/2, and so on, and in a special sense by the heavy recurrent rate of what appeared to be a standard value, namely the width assigned to the steps, benches and beds. It was larger than two, yet smaller than three, and appeared to make sense only if interpreted as 21/2.

I was puzzled by these observations until it occurred to me that the conditions which they reflected may be related to the possibility that the inventor of the scheme availed himself of a scale that was not based on the continuous sequence of equal numerical values used in the decimal system, but emerged from the geometrical thinking of the developmentally older sedecimal system that survives in the subdivisions of the English inch. I consequently designed a scale in which the value forty was internally graduated into sixteen units, each of a length of 21/2 feet, and the entire riddle of the plan unfolded itself.

I shall demonstrate the validity of this assertion with a scale analysis of two areas of the plan which lend themselves with particular ease to this type of investigation.

The 21/2-foot module (standard module)

Fig. 11 shows a scale analysis of the southern transept arm of the church of the plan of Saint Gall. The surface area covered by this part of the church forms a square, each side of which is equal to the width of the nave, i.e. 40 feet. In the second and third drawing shown in Fig. 11 this square is subdivided into sixteen strips, first from north to south; then, from east to west; in the last drawing the two systems are combined.

The experiment proves that all the internal area divisions of the southern transept arm are conceived as multiples of a 21/2-foot square. The passage way that gives access to the crypt is 3 units wide and 16 units long (71/2 feet x 40 feet), the platform on which the altar of St. Andrew stands is 3 units wide and 10 units long (71/2 feet x 25 feet). The steps and benches have a standard width of 1 unit (21/2 feet) and vary in length between 5, 6, and 10 units (121/2 feet, 15 feet and

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91 For details see Walter Horn, "The Plan of St. Gall—Original or Copy?", 96ff.

92 Ibid., 97ff.
25 feet). The intervals between the steps and benches likewise can be brought into a system of logical relationships, if interpreted as multiples of a 2\(\frac{1}{2}\)-foot square.

An analysis of the adjacent area of the dormitory of the monks (Fig. 12, top drawing) establishes this point with even greater persuasiveness. The complicated layout of the beds in this building is inconceivable without the use of a carefully constructed system of auxiliary construction lines. It is easily understandable if it is conceived as being developed within a grid of 2\(\frac{1}{2}\)-foot squares (Fig. 12, bottom drawing). The overall analysis of cloister and church suggests that the building was meant to be sixteen 2\(\frac{1}{2}\)-foot units wide and thirty-four 2\(\frac{1}{2}\)-foot units long (40 feet x 85 feet). Each bed is 1 unit wide and 3 units long (2\(\frac{1}{2}\) feet x 7\(\frac{1}{2}\) feet), with the exception of a small number of beds near the two gable walls which had to be shortened to leave sufficient room for the entrances and exits located in these walls. A glance at the drawings shown in Fig. 12 discloses that the boundaries of the beds do not in all cases coincide with the boundaries of the underlying squares. The beds that lie at right angles to the long wall straddle the grid lines with their center axis. This suggests the possibility of the use of an even smaller module, which we shall discuss later.

The superimposition of the square grid on the original drawing (Fig. 12, center drawing) reveals how the draftsman, in copying this building, extended its length by one unit beyond what it was meant to be through an accumulation of small errors. The center group of beds in the northern half of the dormitory has a length of twelve 2\(\frac{1}{2}\)-foot modules. The corresponding group of beds in the southern half of the building is thirteen 2\(\frac{1}{2}\)-foot modules long. It is obvious that they were meant to be of identical size. The center drawing of Fig. 12 shows with great precision where the draftsman took on these additional increments of space (first and second transverse row in the southern half of the building). This was probably due to two slight and almost imperceptible shifts in the relation of the original parchment to the tracing sheet. By the time the draftsman had reached the end of the second row of beds, he had inadvertently picked up an excess of an entire module. This lengthened the dormitory from 34 to 35 standard modules, or from 85 feet (length of the original) to 87\(\frac{1}{2}\) feet (length of the copy).93

In analyzing the dimensional layout of this as well as any other building of the plan it is important that the overall dimensions of each respective structure be ascertained by its relation to neighboring or superordinate units before an attempt is made to decipher its internal relationships.

**The 40-foot module (large module)**

This module controls the proportions of the church and the layout of the *claustrum* (Fig. 13). The transept and nave of the church, being of equal width, by necessity form a square at their area of intersection. As is the case in certain Romanesque churches of Normandy and the Rhineland two centuries later, the dimensions of this square determine the layout of the remaining portions of the church. Thus on the plan of Saint Gall the transept of the church forms an oblong composed of three times the area of the crossing unit. The nave is a space composed of 41\(\frac{1}{2}\) such units, while 3 more units of identical size are added to the east of the transept: the choir, the sacristy, and the library. It should be noted that in the nave the squares are arranged in such a manner that the corners coincide with the axis of each column. The 40 feet assigned to the width of the nave must for that reason be interpreted to relate not to the clear span between the bases of these columns, but to the distance from axis to axis of each corresponding pair of columns.

That the church of the plan of Saint Gall is laid out according to a system of squares has been observed by many previous students, but a fact that appears to have been entirely overlooked is that the entire aggregate of buildings forming the *claustrum* is developed in a similar manner.

A glance at Fig. 13 shows that the body of the church can be inscribed into a grid of 40-foot squares (3 units wide and 9 units long), and the claustral structures that abut the church to the east can be entered into an adjacent grid of identical squares (3 units wide and 5\(\frac{1}{2}\) units long). I have no doubt that this is the manner in which the drawing was started. But attention must be drawn to the fact that the alignment of the drawing with the grid is not perfect. There are two discrepan-

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93 Konrad Hecht, "Schema oder Bauplan?" 178, observed that the square grid of the schematic drawing of the dormitory, which I published in fig. 7 of p. 91 of the above-named article, is shorter by one standard module than the drawing (16 x 34 units); he tried to correct my "mistake" by a square grid measuring 16 x 35 units. The mistake is not mine, but that of the draftsman who traced the plan of Saint Gall.
cies—not large, yet conspicuous enough to cause some concern.

One of these is that the aisles of the church are not 20 feet wide, as one should expect them to be in the light of their explanatory titles (latitudo utriusque porticus pedum xx); instead they measure 22½ feet. The other is that in certain places the dormitory and the refectory extend over the southern boundaries of the 40-foot grid of the claustrum by as much as 5 feet. I believe that these deviations are the result of purposeful modifications undertaken as the drawing progressed from its initial conception into its final stages; and I shall discuss this point in detail later.

The 160-foot module (super module)

The discovery that the church and the claustrum were designed ad quadratum raises the question as to whether the site plan for the entire monastery may not have been developed from the dimensions of the crossing square. To answer this question is not easy, because the plan fails to inform us about the location of the walls that separate the monastery from the secular world. We do not know where the grounds of the monastery begin and where they end. It is probable, however, that this problem may be solved by a simple proportional speculation.

Measured from west to east—or more precisely, from the westernmost fences of the agricultural service structures west of the church to the easternmost lines of the building masses east of the church—the monastery grounds are 16 times the width of the nave of the church (640 feet), a round and very convincing number, in which the figure four plays a determining role (Fig. 14). By contrast, the distance between the outermost lines of the building masses sited along the southern edge of the monastery and the outermost lines of the building masses on the northern side amounts to 11½ times the 40-foot width of the nave of the church. The proportion 11½:16 is not a likely medieval relationship. A more convincing proportion would be 12:16 (or 3:4). There is some evidence, not easily discarded, which suggests that in the south and north the monastery grounds were meant to extend beyond the outer building masses, since the fences of some of the buildings located along the southern and northern border of the monastery site run out into the space which lies beyond these structures, and end only at the end of the parchment. Two such fences, running north, may be seen on either side of the outer school; another runs south in extension of the west wall of the house for the workmen (Fig. 1). There are other considerations of a practical nature which would require a buffer zone between the outer building lines and the monastery wall. The water-driven machinery of the mill and mortar houses are dependent on flues and sluices that can only have run to the south of these buildings, and a similar safety margin of space would have been desirable in the north for servicing the privies.

A buffer zone of 10 feet added to the building masses, on either of the two long sides of the plan, would take care of these necessities and would result in a meaningful overall proportion (12:16 or 3:4) (Fig. 14). The acceptance of such an overall modular scheme would, moreover, help us to settle two other puzzling aspects of the plan:

1) It would explain the location of the church. It has never been clarified why the church lies where it does on the plan. It is obvious that it had to be off-center. Had it been placed in the center of the plan, the southernmost buildings of the claustrum would have been moved to the southern edge of the monastery, leaving no room for the subsidiary claustral structures, such as the monks’ bake and brew house, the mill, and the mortar. But what determined the exact distance by which the axis of the church was to be off-center?

If we assume that the monastery site was calculated as an oblong, sixteen 40-foot modules long and twelve 40-foot modules wide, the entire monastery site could be conceived as having been inscribed into a grid of 12 supersquares, each formed by four 40-foot squares, and therefore measuring 160 feet x 160 feet (Fig. 15). Within the linear frame of reference established by such a grid the difficult problem of the axial position of the church—incomprehensible in terms of the layout of the Roman castrum, with which it has frequently been compared—would find a surprisingly simple explanation. The axis of the church would coincide with the first, the axis of the refectory with the second of the two longitudinal lines of the grid.
(2) The same grid would also explain the transverse division of the monastery into its four principal building sites:

a. a western zone, accommodating the houses for livestock and their keepers and two houses to take care of the knights and servants who travel in the emperor’s following; 

b. a central zone, of twice the surface area of the western zone, accommodating the church, the clausrum, and all of the buildings that lie to the north and south of this complex; 

c. an eastern zone, coequal in surface area with the western zone, accommodating the novitiate and the infirmary, the cemetery, and several other installations.

The western and eastern group of buildings are each inscribed into a surface area formed by three 160-foot squares; the central block of buildings extends over six.

The 1 1/4-foot module (submodule)

There is good reason to assume that in certain installations the inventor of the scheme made use of a submodule by halving his standard module of 2 1/2 feet, thus arriving at the smallest module of 1 1/4 feet. I refer to this unit as a “submodule” because it is used sparingly, in contrast to the 2 1/2-foot unit which is used as a standard module throughout the length and width of the plan. Two-and-a-half feet, as has been pointed out, is one-sixteenth of 40, the width assigned to the nave of the church. One-and-one-fourth feet is one-thirty-second of this measure. The peculiar values 2 1/2 and 1 1/4—strange to anyone accustomed to working with a metric scale—will ring a more familiar tone if it is remembered that, expressed in inches, these units correspond to 30 and 15.

The plan contains a number of installations which cannot be explained in any other manner than on the assumption that they have been constructed on a 1 1/4-foot module.

I shall discuss these occurrences in a more appropriate context. For the present study the 1 1/4-foot module is not of vital importance.

III The Relation to the Carolingian Foot

Having established that the plan was drawn to a consistent scale we must then ask whether this scale was invented for this specific purpose, or whether it was related to any regular Carolingian system of measurement. I believe that the original scheme of the plan of Saint Gall was drawn with a regular Carolingian straight-edge, 40 Carolingian inches long, and that the designer of the scheme established the overall dimensions of the monastery site by assigning to it a length of 40 and a width of 30 Carolingian inches.

The modern English foot is the equivalent of 30.48cm. The classical Roman foot was 29.60cm. The Carolingian foot was larger and, despite Charlemagne’s attempt to standardize weights and measures, appears to have been afflicted by a good deal of regional variation. Kutsch, Schmidt, and Behn in measuring Carolingian churches believed that they were able to establish its length as 34.00cm; Hanftmann and Arens as 33.29cm; Rave as 33.30–33.50cm; and Doppelfeld as 30.04cm. The studies of Felix Kreusch and Leo Hugot suggest that the Palace Chapel at Aachen was built in a Carolingian foot whose length corresponded to 33.30cm. This is the exact equivalent of the old Drusianian foot, which according to the agrimensor Hyginus was in use in the territory of the Tungric and may have been used as the traditional standard measure by the Franks.

The foot used in the plan of Saint Gall, if calculated on its present dimensions, amounted to 32.16cm. However, attention must be drawn to the fact that the parchment on which the plan is drawn was subject to a considerable amount of shrinkage. Even today, as Dr. Duft has observed, when displaying the plan in its show case, the surface of the parchment expands and contracts in response to the changing humidity content of the air. Konrad Hecht, who has made some interesting observations on this subject, estimates the mean loss of shrinkage to which the plan was exposed through the ages to be 5–6 per cent. If we modify the figure obtained from the present shrunken surfaces of the plan by this quotient, the metric equivalent of the Carolingian foot which was used in the plan is more likely to have been around 34.00cm, which would agree with the findings of Kutsch, Schmidt, and Behn.

It could equally well have been the exact equivalent of the old Drusianian foot of 33.30cm, which appears to have been the historical prototype of the Carolingian foot.

Tabulated in their respective order of magnitude, the rela-
tion of the graduations shown on the straight-edge used in designing the plan to the actual dimensions for which they stood are as follows:

1. Surface area of the entire monastery site: 30 \times 40 \text{ Carolingian inches} = 480 \times 640 \text{ feet}.

2. Supermodule: 10 \times 10 \text{ Carolingian inches} = 160 \times 160 \text{ feet}.

3. Large module: \(2^{1/2} \times 2^{1/2} \text{ Carolingian inches} = 40 \times 40 \text{ feet}.

4. Standard module: one-sixteenth of \(2^{1/2} \text{ Carolingian inches} = 2^{1/2} \text{ feet}.

5. Submodule: one-thirty-second of \(2^{1/2} \text{ Carolingian inches} = 1^{1/4} \text{ feet}.

It should be noted that the value of the crossing square (\(2^{1/2} \text{ Carolingian square inches}\)) is developed from the value of the next largest module (10 Carolingian square inches) in the same manner in which the value of the small unit (one-sixteenth of \(2^{1/2} \text{ Carolingian inches}\)) is developed from the crossing square: by the method of binary section.

All the surface calculations of the scheme are determined accordingly, by a geometrical ground relationship in which each smaller base value is calculated as one-sixteenth of the superordinate value: the large module (40 square feet) is one-sixteenth of the super module (160 square feet), the small module (\(2^{1/2} \text{ square feet}\)) one-sixteenth of the large module (40 square feet).

In handling these modules, the designing architect displayed an extraordinary sense of discretion, using each for its specific purpose: the super module (160 square feet) for the calculation of the overall relationship of the site, the location of the axis of the church, and the grouping of the principal building masses (Fig. 15); the large module (40 square feet) for the square schematism of the church and \textit{claustrum} (Fig. 13); the small module for all dimensions that were too small to be expressed by any of the larger modules (Figs. 11–12).

The plan is drawn to a scale in which one foot on the ground corresponds to 1/16th of a Carolingian inch on the parchment (which corresponds roughly to the metric scale of 1:200), a ratio that one would consider even today ideal for a plan of this kind, as it allows for easy readability of details without obscuring primary values.

**IV**

**Purposeful Modifications**

One of the remarkable qualities of the planner of the scheme of Saint Gall is that, although he exhibits an extraordinary sense of sophistication in the working out of modular relationships, he does not hesitate to modify his schematism when special conditions so require. I have already alluded to this fact in my discussion of the 40-foot module. There are two deviations from the use of this module which call for an explanation.

One of these is that accurate measurement of the aisles of the church shows them to be not 20 feet wide as their explanatory title requests (\textit{latitudo utriusque porticus pedum xx}) but 22\(1/2\) feet; the other is that the dormitory and the refectory extend in places as much as 5 feet southward over the 40-foot grid of the \textit{claustrum} (Figs. 13, 15).

What caused these modular incongruities? Are they due to the carelessness of the copyist? Or are they purposeful modifications? The latter possibility was suggested by Arens,\(^99\) the former by Poeschel.\(^100\) Arens thought that the surplus in the width of each aisle owed its existence to the draftsman's desire to provide enough space for the thickness of the walls of the church. Poeschel contends that since the draftsman makes no concessions to the thickness of the walls at any other place, it would be illogical to expect him to do so here.

Although Poeschel's argument is not to be dismissed lightly, I am inclined to agree with Arens. We cannot infer from the fact that the drafter of the plan rendered the walls of his buildings as simple lines that he was unaware of the difficulties that might arise from this method of rendering in the more congested areas of the plan unless they were forestalled by special provisions from the very start. In the case of the freestanding buildings, the linear style of the draftsman posed no problems as the space required for the wall thicknesses in subsequent construction could easily be borrowed from the open yard surrounding the building, and did not have to be subtracted from the building itself. But where a group of major masonry buildings butted against each other, as in the case of the church and the adjacent claustral structures (Fig. 2), the problem was serious. Here the builder

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\(^{98}\) Konrad Hecht, in an interesting paragraph entitled "Das Schwindmass des Planes," in "Schema oder Bauplan?," 194-97.

\(^{99}\) Arens, Das Werkmaß, 63f.

\(^{100}\) Poeschel, "Bericht über die Studientagung," 28.

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\textit{Leo Hugot, "Die Pfalz Karls des Grossen in Aachen,"} (ibid., 534-72.

would have been forced to borrow the space that he needed for the masonry either from the interior of the church or from the contiguous gallery of the cloister, where spatial congestion was undesirable, since this gallery, besides serving as a pas sageway, was also used for the daily assembly of the monks in chapter. To obviate these contingencies the designer introduced two safety measures: first, by increasing the width of the aisles of the church from 20 to 221/2 feet; second, by enlarging the contiguous cloister walk from 121/2 feet (the width of the other three wings of the cloister) to 15 feet. Without changing his style of rendering he thus interposed a safety area 5 feet wide along the crucial line of encounter of church and claustrum. He left it to the builder to determine precisely what the thickness of the walls should be but freed him from the need of invading any of the adjacent spaces with his masonry as the building went up.

It is obvious that the insertion of this safety margin between the church and claustrum would affect the layout of the latter as well as its relation to the square grid. Thus the cloister yard, instead of measuring 100 feet x 100 feet, covers a surface area of 100 feet x 1021/2 feet; the dormitory, instead of measuring 40 feet x 80 feet, as one would expect in the light of the 40-foot module, measures 40 feet x 85 feet; and all the buildings lying at the southern edge of the claustral grid, extend by 5 feet beyond the southern boundary of that grid.

V Conclusion

The foregoing analysis of the construction methods employed in the plan of Saint Gall should dispel, once and for all, the widespread belief that mediaeval architectural drawings were not made "to scale." In contradiction to traditionally prevailing views—but in confirmation of certain observations made by Boeckelmann and Arens—this analysis demonstrates that the author of the original scheme of the plan availed himself not only of a clearly definable scale, but that he applied this scale throughout the entire layout of the plan with full consistency and logic.

From the methods employed in modern scale construction the plan of Saint Gall differs neither in the logic of its graduations, nor in the truthfulness with which this graduation reflects the variations of the rendered object. From the methods of modern scale construction the plan of Saint Gall differs in two points only: first, in the fact that it flows from a basically modular type of thinking; and second, that its basic working units are derived as fractions or multiples from a dimensional master value.

If a modern architect assigns to a given area a value of 40 feet, he does so with the aid of a ruler, on which the value 40 is graduated into 40 equal parts of one. On the scale of the plan of Saint Gall, quite differently, the magnitude 40, as is found, was not subdivided into 40 units of one, but into 16 units of 21/2. Why the author of the plan of Saint Gall divided his 40-foot scale into 16 units of 21/2 rather than into 40 units of one must by necessity remain a matter of speculation. He may have chosen this procedure because of its constructional simplicity. To subdivide a primary value into 16 equal fractions is one of the easiest and, for that reason, also the oldest and most universal geometrical operations of the human mind. The method of continuous halving is an operation requiring no other instrument than a straight-edge and a compass.

On the other hand, in choosing this procedure, the draftsman may also have been influenced by the eminently sacred connotations associated in his day with the two basic figures used in this operation, the figures 40 and 4.

The choice of the figure 40 for the width of the nave can hardly be considered an accident. Forty was a number which in Biblical tradition had been associated for ages with periods of expectation and penitence. Forty were the days of the great primeval deluge, forty the years that the Hebrews spent in the desert, forty the days that Moses passed in expectation on Mount Sinai, forty the days announced by Jonah for the destruction of the city of Ninevaeh, forty the days that separated the Ascension from the Resurrection. Even as late as 1907, Reinhardt remarks: "Comme le dessin de l'église, celui des autres constructions ne peut être pris à l'échelle. Le dessin est purement..."
ments, the four seasons, the four rivers of paradise, the four cardinal virtues, the four main prophets, the four evangelists.

Whatever his reasons may have been (and I shall say more about the number symbolism in my forthcoming book on the plan of Saint Gall) in organizing the layout of his monastery in a manner in which all values could be expressed as multiples of 40 or as multiples of a fraction obtained by halving 40 four times the draftsman provided his plan with a scale that could be read and applied by anybody who was familiar with the principles involved or who knew the formula.

It is due to the relative largeness of its standard unit (2\(\frac{1}{2}\) feet) that the plan owes its easy readability, and that it could be traced upon another sheet of parchment without sustaining any serious loss in clarity and measurability.

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