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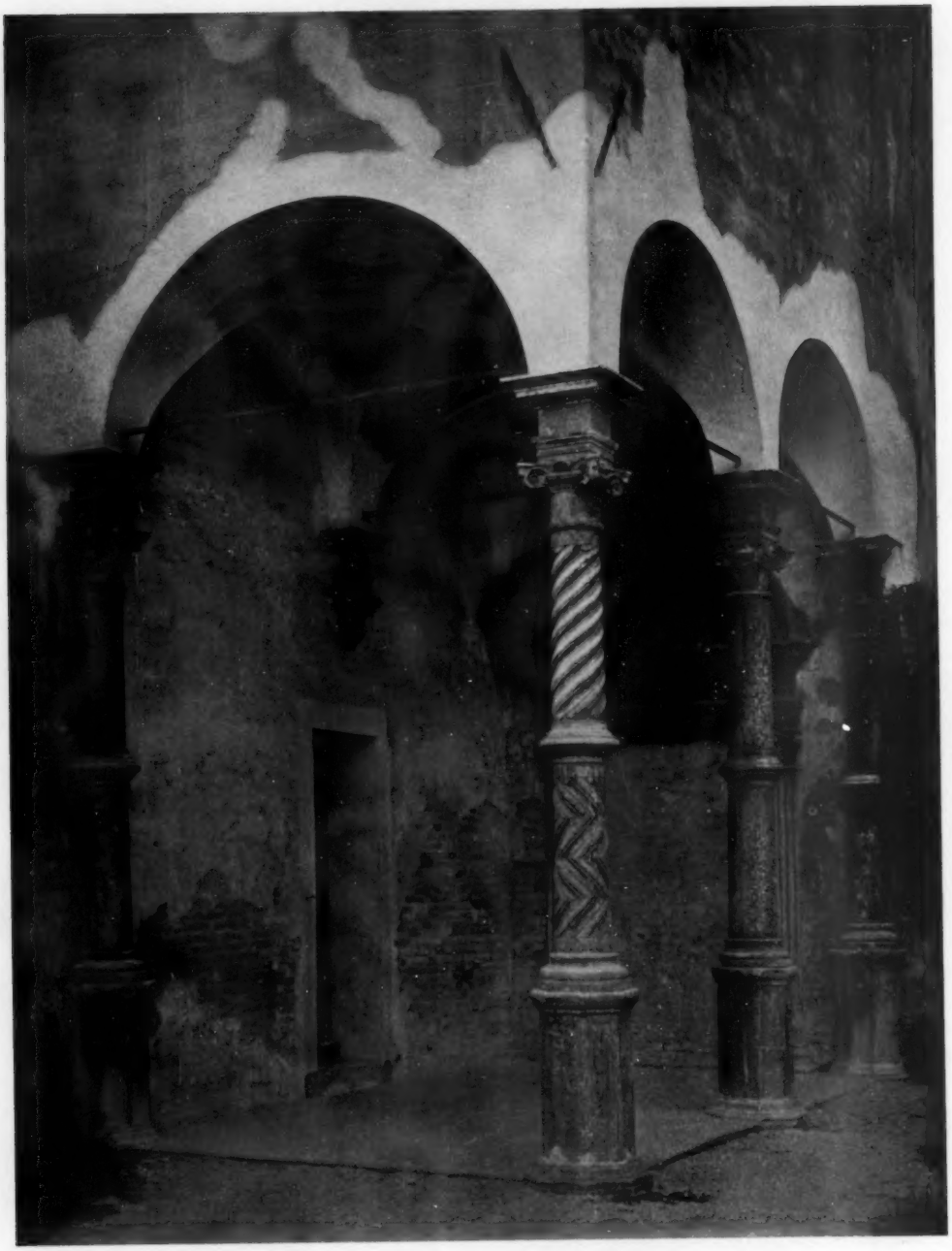
KILHAM & HOLMES ARCHITECTS

The buildings comprise a fireproof garage located between a dwelling for the coachman and one for the chauffeur. The walls are of plaster and the roofs of slate to match the mansion house of the estate.

BRISTOL, R. I.



LOGGIA, CHURCH OF ST. VITALE, RAVENNA, ITALY.

THE AMERICAN ARCHITECT

VOL. XCVII. WEDNESDAY, MARCH 16, 1910 No. 1786

ILLUSTRATIONS OF THE WIDENING REFINEMENT IN THE ARCHITECTURAL EXHIBITION AT THE BROOKLYN MUSEUM

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SIXTH PAPER

ASIDE from two controversial publications in the *Journal of the R. I. B. A.**, which were necessarily almost wholly confined to the Cathedral of Amiens, as regards the widening refinement, and from a brief article in the Belgian Quarterly *Revue de l'Art Chrétien*†, no published account has hitherto been offered of the remarkable exhibits which were procured by the Brooklyn Museum expedition of 1907.

Nearly three years have elapsed since they were obtained, and, as yet, an even approximately comprehensive knowledge of their evidence has been confined to the small number of experts who have examined the enlargements under my personal guidance.

These enlargements were prepared in France and it was consequently possible to show them to M. Auguste Choisy in 1907, but no other French expert has seen them, excepting the *Inspecteur des Travaux* at Amiens. They were shown in London, in September, 1907, to a few prominent members of the R. I. B. A. They were taken to Brooklyn in that month, and up to recent date, and before the recent public exhibition, their existence was only known to five or six American experts. My own estimate of the importance of these exhibits has been shared by the gentlemen who have seen them thus far. They have been universally admitted by these experts to reveal hitherto unsuspected and very remarkable facts as existing in many of the most easily accessible and most widely known churches of northern France.

The peculiar distinction of these exhibits is to have solved the rather difficult problem of obtaining, by photography, satisfactory approximations in measurement, for hitherto unsuspected vertical deflections in mediæval churches, of systematic character, and of frequent recurrence throughout the territory which has been examined. Strange to say, the main drawback to a wider knowledge of the facts discovered is the large size and the great number of the enlargements which furnish the evidence. The large size precludes reproduction, and the great number precludes transportation and compels a personal examination of the installation. Even in case of a personal visit, personal guidance is also necessary for no catalogue or other account has been published of the 1907 exhibits; and the pressure of other museum duties has made it impossible to revise the earlier and existing catalogues, so as to cover the facts brought to light.

It is the object of this paper to draw attention to these exhibits and to connect their evidence with that which had previously been obtained on the same subject.

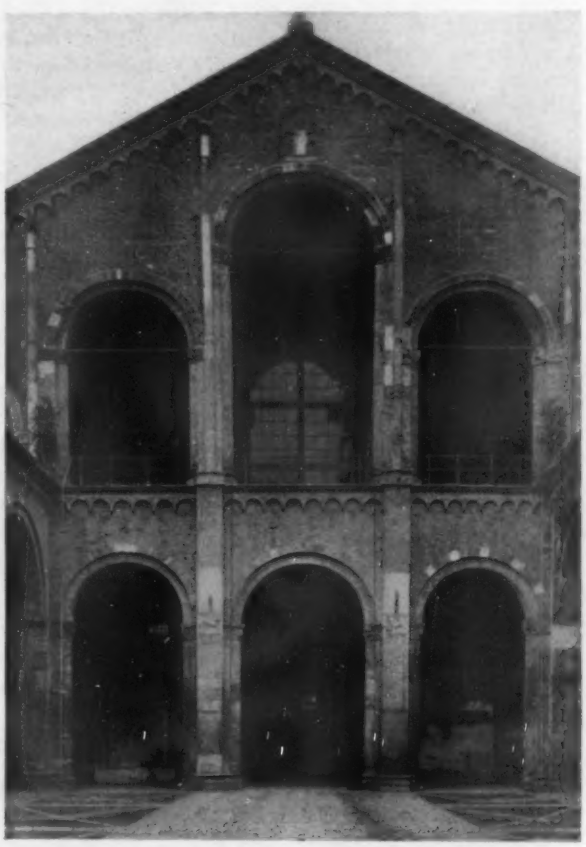

FIG 2. PORCH OF S. AMBROGIO, MILAN
Showing the widened, horse-shoe, form in the central arch, second story.

* Nov. 9, 1907. "Architectural Refinements. A Reply to Mr. John Bilson," and Sept. 25, 1909, "Amiens Cathedral and Mr. Bilson's Rejoinder."

† July, 1908. *"Raffinements Architecturaux,"* with Preface by the Editor, Prof. L. Cloquet, of the University of Ghent.

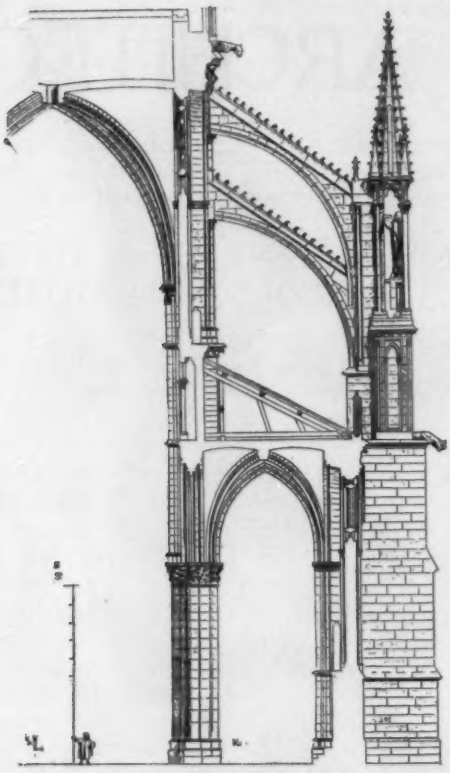

FIG. 1. SECTION OF RHEIMS CATHEDRAL
From the folio publication of Alphonse Gosset.

That the facts are so remarkable as to appear incredible must be admitted, but this admission is tempered by the consideration that the facts are not less remarkable on the theory of accident than they would be on the theory of construction. M. Choisy made the remark when he examined the enlargements that the facts are even more remarkable, if considered as accidents, than they would be if considered intentional. In making this admission that the facts appear incredible, it is also thus conceded that preliminary scepticism is not only justifiable and proper, but also that it is inevitable and even desirable. On the other hand a scepticism which goes to the length of refusing to examine the evidence will probably fall into discredit.

At all events, no one who has examined the illustrations of the widening refinement in Brooklyn, under my guidance, will consider that any abbreviation of their amount or reduction of their dimensions would be advisable or satisfactory, in view of the revolutionary and astonishing implications for the entire fabric of mediæval archæology, which are involved. Considering the great mass of material evidence, including 310 enlargements, of which 171 belong to the 1907 series, it is not so much the mission of this paper, which can present only a portion of this evidence, to prove a case or to discountenance scepticism about it, as it is to say that the evidence exists, to indicate its general character, and to discredit the scepticism *which declines to examine it.*

First and foremost—what is the "supposed" widening refinement? The illustrations of this paper will answer this question as regards the apparent facts. It has also to be shown that these facts are constructive; but if intention be thus proven, it is not absolutely necessary to determine immediately what the purpose was, although this purpose appears to be tolerably clear to many of the gentlemen who have already decided that the constructive intention existed. The question of purpose ought certainly never to be debated on the basis of appearances as found in the photographs, *the photographs being called for because the appearances, as seen, are not the appearances as photographed.* It is, therefore, mainly the mission of these illustrations to suggest what the practically invisible facts, as regards the buildings themselves, are thus found to be, and it is also their mission to indicate the constructive conditions which are held to show that accidental movements, caused by thrust or subsidence, cannot explain the deflections.

As regards constructive conditions, the first point to be attentively considered is that *all the illustrations of this paper represent deflections in straight lines,* whereas in all accidental deflections which are due to the vaulting thrusts, the amount of the accidental movement is naturally greater near the points where the thrust exerts its greatest force, and these are the points nearest to the vaulting itself. In all Gothic churches the resistance to the vaulting thrust of the upper nave increases in the downward direction; first, because the buttresses offer greater resistance as the weight of their loading increases, and second, because the buttresses generally increase in transverse width, in the downward direction. It is a third and most important consideration that the aisle vaults, which are invariably lower than the nave vault in the illustrated examples, not only add to the resisting weight in the downward direction, at a considerable distance below the thrust of the nave vaulting, but they also offer the additional resistance *of a counter thrust toward the nave* at this lower height. (For all these points note Fig. 1.)

Hence, a deflection in the vaulting-shafts of any nave, in straight lines, for the entire height exhibiting that deflection, is on the face of things, presumably not due to vaulting thrust, for in that case the amount of deflection would vary in the descending line, with the amount of resistance. The deflection would tend to decrease in the downward direction and would therefore take the form of a gradually diminishing curve or of a series of bends with a gradually diminishing pitch. *It has never been known to experts, or to anyone else, that these deflections in straight lines existed in mediæval buildings until thesephotographs were taken,* and most of the photographs showing deflections in straight lines were taken during the latest expedition, that of 1907.

There are two kinds of widening in straight lines. In one type the inclinations begin at the pavement. In the other type they begin immediately above the capitals of the arcade piers, which are themselves perpendicular. The point that the piers themselves are perpendicular in such cases, is material; because, if they leaned into the nave, a return bend in the vaulting-shafts might be attributed to accident.

Plate 1 represents the first type, as found in the church of St. Alpin, at Châlons sur Marne. The apse of the Balaban Aga Mesjid Mosque at Constantinople, the church of St. Loup at Châlons, the church of St. Ouen at Rouen, the Cathedral of Rouen (plates

2, 3, 4, 5), and the Cathedral of Trani (fig. 3) are additional examples shown in this paper. St. Remi at Rheims (fig. 7) represents the second type. The cathedrals of Laon, Rheims and Amiens are additional examples shown by this paper (fig. 6, plates 9, 10, 11). The illustration for Laon (plate 11) is taken from the central choir window, and here the widening is in straight lines, from the sill up, but the church itself corresponds to St. Remi in proportions and construction of the widening, although of larger size.

Although the consideration of purpose has been waived, it may be added that, when a rectilinear inclined vaulting-shaft is superimposed on a perpendicular pier, the effect for the eye in the cathedral is that of a vertical curve.* This fact ought not to be overlooked when the aesthetic purpose is considered. It is a peculiar importance of the 1907 photographs to have very much increased my own knowledge as to the existence of rectilinear inclinations which produce the effects of curves. It may also bear on the consideration of æsthetic purpose to observe that the mere fact of inclination in the piers or vaulting-shafts is not so significant in these various illustrations, as is the horse-shoe form produced by the union of the leaning vertical lines with the arch. This is an especially important point, because the earlier instances of widening are Byzantine or Romanesque and not Gothic. If any of the facts are admitted to be constructive, it must also be admitted that the Gothic use is derived from the Romanesque and Byzantine periods. Inasmuch as an increase in relative narrowness and relative height of proportion is a well-known feature of Gothic art, as well as an increase in actual height, it follows, when the original aesthetic purpose is in question, that the lower and wider Byzantine and Romanesque proportions should be considered first. In these, or in early Gothic, the ordinary horse-shoe form is more easily apparent, as in the door of St. Mark's at Venice (plate 12) or in the interior widening effect of the same church. We may, however, still describe *the appearance* at Amiens, or Rheims, as that of a vertical and outward receding curve, in combination with an attenuated horse-shoe form, but it ought not to be forgotten that this attenuated horse-shoe form is derivative from a form of wider proportions, *if any widening effects whatever are admitted as constructive.*

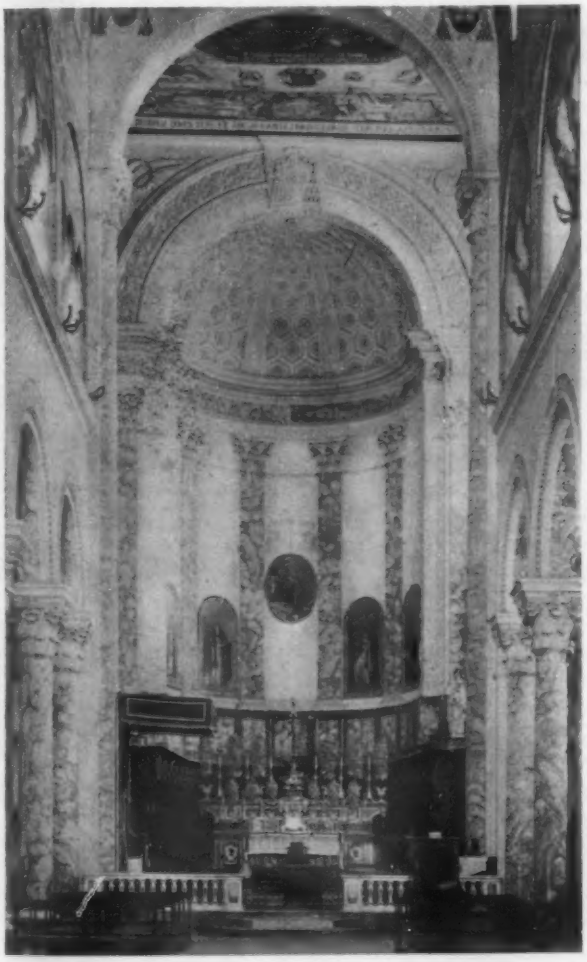

FIG. 3. CATHEDRAL OF TRANI
The pilasters at the crossing widen 10 inches, in straight lines beginning at the pavement, against the abutment of the transept walls.

*The so-called horizontal curves of the Greek temples are constructed in straight lines, with a series of bends, which give the effect of curves. See plates 10, 11, of Penrose, *Principles of Athenian Architecture.*

As to the question of construction, probably the most immediately convincing proof that neither thrust, nor lateral subsidence, can explain all the cases of the supposed widening refinement which have been observed, is offered by its appearance in an apse which is constructed, and imbedded, in a solid wall. Such an instance is offered in plate 2, in the apse of a small Byzantine church at Constantinople, now known as the Balaban Aga Mesjid Mosque, which is situated north of the ruined aqueduct of Valens. Equally adequate resistance in the way of abutment is found in the apse of the Capella Palatina at Palermo, in the apses of the Cathedral of Borgo San Donnino, of St. Radegonde at Poitiers, of the Schottenkirche at Vienna (A. D. 1638) and in the choir of S. Giorgio Maggiore at Venice, all of which exhibit the supposed widening refinement.*

The central arch in the second story portico of the facade of S. Ambrogio at Milan (fig. 2) and the main door of St. Mark's at Venice (plate 12) also offer instances of the debated horse-shoe form, which appear to be convincing cases, as regards the elimination of accidental causes. Certainly the form of the doorway of St. Mark's cannot be attributed to thrust.

The Cathedral of Trani (fig. 3) offers another illustration of the widening refinement which ought to be equally convincing. The church is not vaulted and the thrust of the light arch which unites the crossing piers is quite insignficant. The abutment, which is furnished by the transept walls, which are of great depth, has only to be mentioned to be appreciated. Thus we are called on, by the agnostic or the sceptic, to suppose that the insignificant thrust of this light arch has not only produced an accidental widening of 10 inches, but also that this thrust has operated in straight lines down to the pavement, which is certainly incredible.

* Only the two latter instances are represented in the exhibition. S. Giorgio Maggiore and the Schottenkirche are the only two Renaissance cases so far known, and it may be presumed that they represent rare instances of survival, in a period which was notoriously hostile to Gothic art.

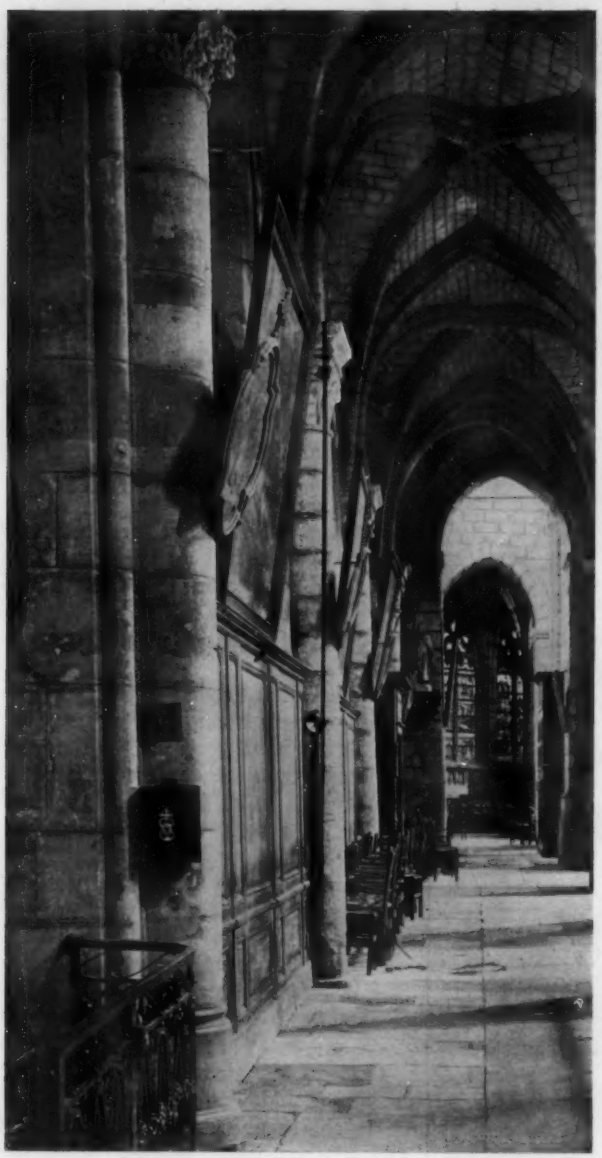

FIG. 4. ST. ALPIN, CHÂLONS. LEFT AISLE
Plumb-line and surveyor's rod at the second respond. Inclination 4 inches in 14 feet. The masonry courses of the transverse chapel walls are seen to be horizontal. The facts are uniform throughout both aisles. For the choir of this church see plate 1.

No doubt there is one difficulty about such instances. They might be manufactured by a tilted camera, and it is easier to presume that they are, than it is to visit Trani or Constantinople, and verify the facts. The crossing piers of Notre Dame at Paris are nearer home, but in lofty churches the perspective convergence corrects the widening effect and brings the lines into an apparent perpendicular, so that the divergence may be either held to be inappreciable, or insignificant, or may pass entirely unnoticed. The fact that the widening effects do pass unnoticed cannot be disputed, and this, of course, constitutes their claim to being refinements, if constructive. The widening effects are much more apparent in a photograph of large size than they are in a cathedral. This is the advantage and the disadvantage of the photograph. The facts are often so obvious in photographs that even the expert cannot realize that they are constantly overlooked in the original buildings. They are often also so obvious in photographs that the effect appears ugly. On the other hand, the expert who knows that the supposed facts have been overlooked, also knows that a tilted camera might produce the same appearance. It may, of course, be mentioned that as much as twenty or thirty minutes have been frequently devoted to adjusting and levelling the camera for a single exposure, and that the number of views from a given nave will frequently be more than six or eight, occasionally exceeding the twenties, thirties or even fifties, and that the law of chances will prevent the camera from being tilted the same way on all occasions.

All these things might be mentioned, but it is better to hang up a plumb-line. The perpendicular has, in fact, been established by a plumb-line in the Balaban Aga Mesjid, and such a line was also suspended when the door of St. Mark's was taken, although it does not show clearly in the picture.

The 1907 photographs are, however, unique in this particular, of always exhibiting the plumb-line close to the line of deflection. We may realize from the photographs of the Balaban Aga Mesjid apse, of the Trani crossing piers, of the S. Ambrogio portico, and of the St. Mark's doorway, which represent earlier dates, and earlier expeditions, what great advantages may be claimed for the 1907 photographs of St. Alpin and St. Loup at Châlons, of St. Ouen and of Rouen Cathedral, of St. Remi and the Cathedrals of Laon, of Rheims and Amiens.

In the former cases, although the camera plate may be admitted to have been strictly perpendicular, it is still necessary to use a compass on the photograph, in order to determine that a widening exists. In the latter cases the plumb-lines tell their own story.

As regards measurements in the case of the Trani photograph, it is necessary to know either the height of the piers or the width of the nave, before the amount of the widening can be computed from the compass test. The surveyor's rod (with a disk of 5½ inches diameter) will be seen on the plane of the desired measurement, in the photographs of St. Mark's doorway and of the Balaban Aga Mesjid apse, but in the 1907 photographs the compass can be carried directly from the given deflection, as shown by the plumb line, to the adjacent disk on the same plane. This disk, in the 1907 series, is generally an oblong of 8 x 10 inches, divided into half widths of 4 and 5 inches, which show white and black contrasts in the picture. See, for instance, fig. 6. Minuter subdivision of these halves is again possible with the enlargements.

Thus the measurements for the widening of the piers next the choir in St. Alpin (plate 1), as tested on the oblong disks, which are close to the piers and on the same plane, are 1¾ to 2 inches to a side, in a height of about 21 feet.

We have next to inquire about the resistance to vaulting thrust in St. Alpin. The answer is offered by a view in the exhibition, which shows the same piers, with their abutments on either side. The great thickness of these transverse abutment walls will not escape notice. For this transverse wall set also fig. 4.

Although it appears sufficiently certain that thrust alone could not have carried over these abutments, as shown in fig. 4, so as to produce inclinations of the piers, which begin at the pavement and continue in straight lines, it may be thought that subsidence of the exterior walls and foundations, added to the force of thrust, might have produced this result. Aside from the reflection that such subsidence would probably not have been equal on both sides in one church and certainly would not have been equal, on both sides, in all the cases to be subsequently cited, we are able to show by fig. 4, of the aisle of St. Alpin, that such subsidence has not occurred. The masonry courses of the responds and transverse chapel walls are seen to be horizontal, and not tilted downward in the outward direction, and the widening effect is obtained in the aisle, on the outer side, by a battering construction in the end of the transverse chapel wall.

We will immediately associate with fig. 4 the illustration of fig. 5 for the aisle of St. Loup at Châlons, also plate 6, showing the aisle responds of Rouen Cathedral. Plates 7 and 8 show the aisle responds of Rheims and Amiens cathedrals. Similar and additional instances may be quoted offhand for the aisles of St. Jacques at Châlons,* of the Thomaskirche at Strassburg,* of S. Ambrogio* and S. Eustorgio* at Milan, of S. Michele and S. Francesco at Pavia, for the aisles of the Church of Saint Quentin* at Saint Quentin and for the aisles of the Cathedral of Noyon.* It should be carefully noted that *none of these instances relate to outward leaning walls.* On the contrary, all the quoted, and all the illustrated, cases are instances of *inclined responds,* which face transverse chapel walls or transverse transept walls, except the two following cases. In Rheims Cathedral the facts are noted for the responds (plate 7) and not for the walls, and the exterior buttresses are of notorious strength and solidity. The resistance at Amiens for the aisle responds (plate 8) is 25 feet deep and at Noyon it is 17 feet deep without including the wall and exterior buttresses. In Rouen Cathedral it is at least 14 feet deep without including the wall and exterior buttresses (plate 6). The resistance in St. Alpin is 9 feet deep in the right aisle (compare fig. 4, left aisle). Fig. 6 speaks for itself, as regards the amount of transverse resistance in the aisles of St. Loup at Châlons.

FIG. 5. ST. LOUP, CHÂLONS. LEFT AISLE, LOOKING TOWARD ENTRANCE

Plumb-line and surveyor's rod at the second respond. The inclinations of the responds are found in both aisles and vary from one to three inches, with a line of 9 feet. For the choir of this church see plate 3.

One of the most convincing general arguments for the existence of the widening refinement is found in the general uniformity of the inclinations of the different aisle responds in a single aisle, and in the uniformity of the inclinations on two sides of a given church. Such instances of equality at points far removed, and in so many cases, would be astounding if produced by accidental movements, and wholly impossible according to the doctrine of chances, which is also the law of common sense probabilities.

Without dwelling longer on this important matter of the aisle responds, we will continue our illustration of the naves of churches with the widening in straight lines, which begins at the pavement, by citing the instance of St. Loup at Châlons (plate 3). Here is a peculiarly convincing illustration, because the piers at the choir are built into the end walls of the aisles. On account of the resistance offered by these walls the piers would bend outward above the level where this resistance ceases, if vaulting thrust had occasioned these inclinations. The following certificate was furnished in 1907 by the architect in charge of repairs in St. Loup:

Certificate of M. A. Aubertin (Translation).

I, the undersigned, Albert Aubertin, architect at Châlons-sur-Marne, author of the spire and other works of repair on the Church of St. Loup, consider that the very visible inclinations of the four great piers at the transepts, and of the pillars of the aisle chapels, are not the result of thrust; but that their condition dates from the construction of the church.

Here is an effect designed by the builder, and the arches thus display a sort of horse-shoe form, destined to correct, or rather to modify, the effects of perspective.

The inclinations begin at the bases of the piers; there are no defects in the adjacent masonry, either in the walls or in the vaulting ribs or vaultings.

Given at Châlons, 27th June, 1907.

A. AUBERTIN.

The instance of St. Ouen at Rouen (plate 4) is of peculiar interest, on account of the importance and great fame of the church, which has these wholly unknown, and hitherto wholly unsuspected, uniform inclinations in the piers of the nave. That the inclinations in minor churches at Châlons should have passed unnoticed may

* The instances with stars are illustrated in the exhibition.

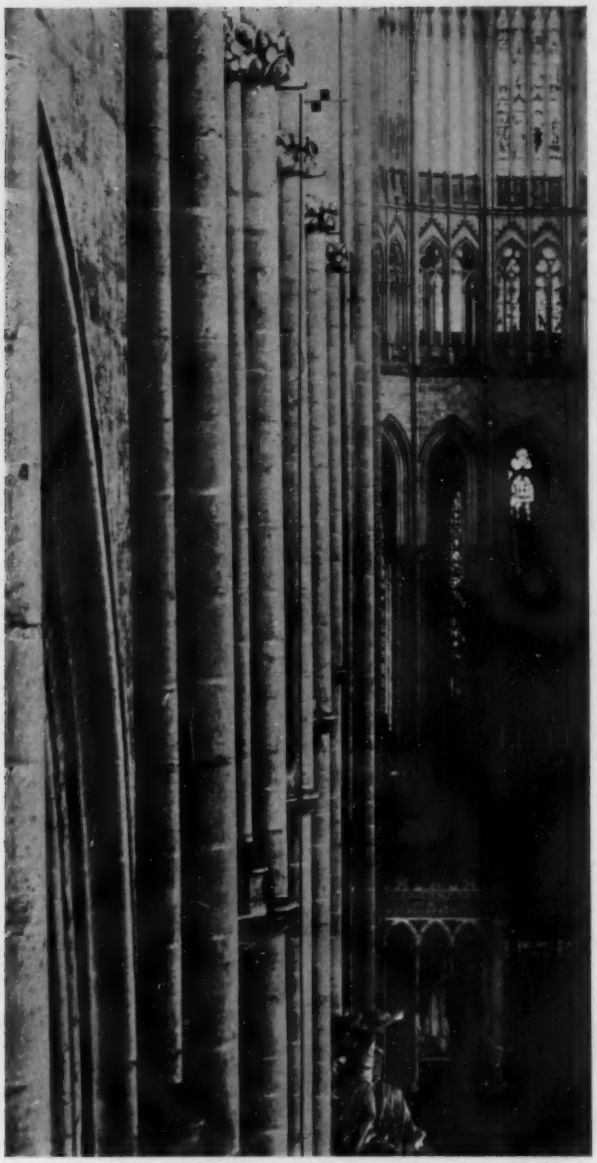

FIG. 6. AMIENS CATHEDRAL. NORTH SIDE, LOOKING EAST
Plumb on third pier from crossing, showing the pier as perpendicular below the arcade capital and the vaulting shaft as deflected outward above the arcade capital. (One of 12 similar details.) Surveyor's disk (8″ x 10″) on the plane of measurement above the carved stringcourse; giving, by compass test, 4 inches deflection between the capital and the stringcourse. The inclination of the entire vaulting-shaft is 8—9 inches. Compare plate 10.

not be surprising, but St. Ouen is one of the best known churches in Europe. Moreover, after examination of this church in 1903, *I announced in two separate publications that the piers are perpendicular.* Professor Charles S. Hastings, Professor of Physics in the Sheffield Scientific School of Yale University, who has taken great interest in the widening refinement and who has made many original observations, also examined this church some years ago *and also decided that the piers are perpendicular.* It may be added that both of us were looking at the time for bends or curves rather than straight inclinations. In 1907 I found, to my astonishment, that the Cathedral of Rouen (Plate 5) has piers inclining in straight lines from the pavement up; having previously, in 1903, supposed that these lines are curves or bends. This suggested to me that St. Ouen, where I had found no vertical curves, might possibly have the rectilinear inclinations. No sooner had I entered the church than I found this to be the fact.

The plumb-line test (see plate 4) gives 6½-7 inches inclination to a side, in a height of about 80 feet. In actual vision the perspective convergence brings these lines into an apparent perpendicular, unless very close attention is given and unless a plumb-line test is used.

Professor Hastings was much surprised when he learned of these inclinations in St. Ouen, but after testing the photographs which his daughter had made in the church, he was able to measure the angle of inclination by scientific instruments and methods which are familiar to physicists and astronomers. These methods were described in his remarkable article which appeared in the *Architectural Record* for August, 1909. His computation, based on the measurement of the angle of inclination by a "dividing engine," coincided with my own computation, based on a photographed plumb-line and on a compass test applied to the 8 x 10 disk in the photograph, within one-third of an inch. The inclinations in St. Ouen are uniform on both sides and throughout the church, including the choir. Such uniformity could hardly be the result of physical accident, even admitting that the resistance of the counter aisle thrust had been insufficient to cause a bending line.

There is, however, an additional and crucial point which has been made known by M. Lefèvre-Pontalis, the editor of the *Bulletin Monumental.* When this gentleman published his adverse critique, mentioned in my last paper, it was some years before I was aware of the rectilinear inclinations in St. Ouen. The critique mentions this church as the *only one* exhibiting an intentional inclination and mentions this to be an *inward* inclination of the *buttresses* which support the flying buttresses, midway between the clerestory walls and the exterior abutments.*

Thus we know from M. Lefèvre-Pontalis that the buttresses of St. Ouen lean *inward,* which they certainly would not do if the interior piers lean outward as a result of vaulting thrust.

The piers in the nave of Rouen Cathedral (plate 5) are shown by the photographs of 1907, to lean out in straight lines from the pavement, about 12 inches to a side. Again, we have to consider the weight and counter-thrust of the aisle vaults as rendering it wholly incredible that a nave vaulting thrust should operate in straight lines down to the pavement. In the photograph of the aisle responds of Rouen Cathedral (plate 6) we find a rectilinear inclination of 8 inches, in a height of 38 feet 9 inches, on the plane of the photographed plumb line.

Aside from the illustrations of this paper the following churches can be quoted for inclinations in straight lines, which begin at the pavement: the Thomaskirche, Strassburg, the Byzantine church of St. Mary Diaconissa at Constantinople (on the entrance side; there are bends

* Le seul exemple d'inclinaison prémeditée d'unc pile faite par un architecte du moyen age est précisément celui que M. Goodyear n'a pas cité. A SaintOuen de Rouen, les ares-boutants à double volée s'ppuient sur une pile intermédiaire entre les culées et les murs de l'êdifice. *Or, cette pile est volontairement penchée en dedans, c'est-à-dire vers l'intérieur de l'église,* parce que la poussée tendait à la redresser et à la faire déverser du coté extérieur. *Bulletin Monumental,* 1905, p. 375.

on the choir side), the church of the Monastery of the Chorah at Constantinople, the Cathedral of Perugia, the church of S. Ambrogio at Milan and the church of Sta. Maria della Pieve at Arezzo (all represented in the exhibition).

After my remarkable experience in observing the piers of St. Ouen to be perpendicular, it is probable that this list may some day be enlarged. It has, in fact, already been enlarged, as will appear from independent authorities to be quoted later. Among these is Prof. Hamlin, of Columbia University.

The multiplication of quotable examples does not, however, appear to be as important as the insistence on the point that the inclinations in certain very celebrated churches have been wholly unknown to the most distinguished experts in Europe. Under these circumstances the observations ought to have great value for engineering experts, whatever explanation might be offered of them. Any decision that the facts are accidental ought, at least, to be accompanied by a very emphatic recognition of the services rendered to the problems of statics and of engineering by the debated photographs.

FIG. 7. ST. REMI, RHEIMS

Plumb-line, showing the piers as perpendicular to the arcade capitals, with vaulting-shafts receding in straight lines above the capitals, against the weight and thrust of the aisle vault and vaulted gallery. Surveyor's disk at the base of the second pier. Compass test indicates inclinations in the vaulting-shafts of about 6 inches to a side, in about fifty feet (above the arcade capitals).

M. Choisy's numerous letters, as quoted in my last paper, are not the only proofs that the existence of these inclinations has been unknown, and a rehearsal of my experience, in 1901, with the architect in charge of repairs in St. Mark's at Venice may be an interesting prelude to an account of a similar experience, in 1907, with the architect in charge of repairs of the Cathedral of Rheims.

The original observations of the widening refinement in St. Mark's were made in 1895 and the original publication of the facts was made in 1897.*

In 1901, I visited Italy expressly for the purpose of making the acquaintance of Commendatore Pietro Saccardo, the architect in charge of repairs of this church. Our first interview took place at his apartments, and on this occasion I was received with formal politeness, and with unqualified scepticism as to the subject-matter of my visit. Commendatore Saccardo gave me the advice that the accidental movements in the church would be sufficient explanation of the alleged phenomena. He agreed, however, to meet me at the church on the following day. Our next meeting thus took place in the front vestibule and in front of the main (inside) door. As soon as we had shaken hands the architect pointed upward to an accidental parting in the crown of the arch over this door, as illustrating the accidental movements in the church. To my inquiry as to the width of the parting, he replied that it was 10 centimeters. My answer was: "Come inside and I will show you a widening of 84 centimeters." We spent two hours in the church, and when at parting I asked for an official certificate, Saccardo said to me: "Any favor which you may ask I will grant, provided you do not ask for the keys of the church," meaning that this would be a request to surrender his office. A few days later he gave me the certificate which is published in the Exhibition Catalogue, and up to the time of his death, in 1904, he did everything in his power to make the facts which had come to his own knowledge more widely known to others.

My experience, in 1907, with M. Léon Margotin, the architect in charge of repairs in Rheims Cathedral, was similar to the one above related. I had called upon him for a photographing permit and mentioned that I was also desirous of obtaining an official certificate for the existence of a constructive widening in the cathedral nave (plate 9). M. Margotin replied that he did not understand this request, and taking down from his book shelves the folio publication of Alphonse Gosset, turned to the transverse section of the cathedral and asked me to point out, in the drawing, the peculiarity referred to. I explained to M. Margotin that this was impossible, because the section was incorrect. The upshot of the interview was an agreement to visit the cathedral next morning. At that time and on our way from M. Margotin's office he stopped at the *Chantier* and asked the *Contre-maître des travaux*, M. Martin, to go with us.

We entered the nave together, and as it happens that

* *Architectural Record*, Vol. VII, No. 2.

the chandelier chains are very numerous, and are so hung in this nave as to allow of their use in sighting on the piers, the two gentlemen immediately admitted, after sighting on these lines, that the piers are perpendicular and without inclination into the nave, and that outward inclinations in the vaulting-shafts begin at the arcade capitals *which they had never noticed before.* They also agreed that these inclinations are in straight lines from start to finish. I then pointed upward to the weight and counter thrust of the aisle vaults and the gentlemen immediately agreed that a nave vaulting thrust could not have operated in straight lines down to the capitals of the arcades and that inclinations due to nave vaulting thrust would have an increased deflection above the line of the triforium, on account of the diminution of resistance in the rising line (compare fig. 1). M. Margotin's certificate is now published for the first time in this country:

Certificate of M. Léon Margotin (Translation).

Sir:—I am pleased to have been able to verify, and with great interest, certain deflections (*déformations*) in our cathedral.

In fact, and as you have been kind enough to point out, I have been able to observe that at Rheims the piers of the nave have preserved their perpendicular, but that, above the capitals, they diverge gradually toward the exterior up to the springing of the vault.

These deflections, also observed by you in other buildings of our territory, appear to me intended by the architects who were charged with the construction of these monuments and to have been arangements of construction.

They cannot be attributed to a lack of resistance in the powerful flying buttresses at Rheims, especially since these same deflections are verified in all the piers and even near the transepts, where the masonry constructions make any thrust from the vaults impossible.

In my opinion, we must recognize certain effects of grandeur as having been purposed, which are wholly to the advantage of the edifice.

L. MARGOTIN,

Architecte diplômé du Gouvernment, Inspecteur des Travaux à la Cathédrale de Rheims.

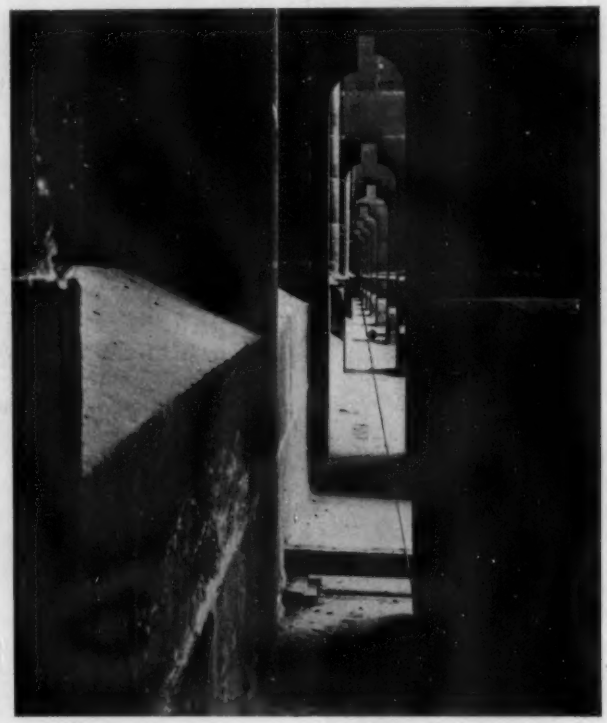

FIG. 8. RHEIMS CATHEDRAL, SOUTH CLERESTORY PARAPET, LOOKING EAST

The clerestory windows are on the left, buttresses and exterior on the right. The line, stretched from end to end of the parapet, shows a curve in plan, convex to exterior, of 10 inches. Surveyor's rod at the centre. Similar curve in the north parapet.

My experience, in 1907, with M. Réné Favry, the *Inspecteur des Travaux*, at Amiens, was equally interesting. For a period of fourteen weeks the intercourse between M. Favry and myself had been limited to the initial interview in which he provided me with the assistance needed in my work. Meantime, I gathered from a slight appearance of coolness on his part, during casual and accidental meetings, that he was not an enthusiastic believer in the widening refinement, which we had never discussed, but which he knew to be the subject of my studies. At the end of fourteen weeks sixty 20 x 24 enlargements of the Cathedral (fig. 6, plates 8, 10) were transported to the *Sacristie des Chanoines* and M. Favry was invited to inspect them. It should be premised that the chandelier chains at Amiens cannot (as at Rheims) be pressed into service as plumb-lines. They do not hang in favorable positions for such use and they are, moreover, very crooked, being made of linked bars which join one another at various angles.

Up to this time M. Favry had, therefore, never known that all the piers on the north side of the Amiens nave are perpendicular.* He had believed that they lean into the nave, thus possibly involving an accidental return bend in the vaulting-shafts. This is the general opinion of experts regarding this cathedral, and this opinion is due to an optical illusion. In fact, there are two optical illusions which cause this belief. The lines of the vaulting-shafts, which really lean outwards, are naturally assumed by the eye to be the true perpendiculars. This causes the piers to appear to lean into the nave by effect of contrast. On the side of the aisles there is another illusion which is produced by the vaulting ribs. Because acute angles are always assumed by the eye to be wider than they actually are, the acute angles formed in vision by the meeting of the lines of the nave arcades with the lines of the diagonal aisle ribs, give an illusive inclination to the piers.

It is, therefore, impossible, either at Amiens or at Rheims, not to believe that the piers lean into the nave, when they are examined in the aisles. To obtain any conclusive knowledge on this subject at Amiens it was necessary to hang a plumb-line at every pier. There is no means of convincing an expert on this subject as regards Amiens Cathedral, excepting to show the plumb-lines in position, or else to make a photographic enlargement for every pier, which includes a plumb line. This is what has been done. If one wishes also to offer convincing proof that the vaulting-shafts all

* On the south side two are perpendicular and four have insignificant inclinations, varying from 1 inch to 1¾ inches. These were doubtless caused by aisle thrust during construction and before the loading of the upper construction had been added. Such loading may be presumed to have held the aisle thrusts in check, after the cathedral was completed.

begin to incline outward at the same relative point, *i.e.*, directly over the arcade capitals, and if one wishes to so measure the inclinations that the statements as to measures can be controlled and tested, it is again necessary to photograph each vaulting-shaft in detail, for the section between the capital and the triforium, with a surveyor's disk on the plane of measurement. This has also been done at Amiens for every vaulting-shaft in the nave; fig. 6 represents one of these twelve 20 x 24 enlargements.

As these pictures were shown successively to M. Favry, his interest and surprise were enthusiastically expressed. So quickly was his conversion accomplished that, before the interview closed, he had announced his theory to explain the widening refinement, viz., that it was intended to correct the perspective convergence.

This suggestion has been made by others, notably by Professor L. Cloquet, in the *Revue de l'Art Chrétien*. I do not wish to antagonize it, but it appears to overlook the Constantinople apse (plate 2) which is only 12 feet high, and instances like the main door of St. Mark's, or the portico of S. Ambrogio. My own disposition is to consider the suggested motive as a concurrent and plausible explanation, especially in lofty Gothic buildings, and from the point of view that a narrowing effect, due to a perspective convergence in lofty naves, would have been especially disagreeable to a taste which had originally preferred the horse-shoe effect and the vertical outward bending lines, for other æsthetic reasons.

M. Georges Durand, the author of the great monograph on Amiens Cathedral, has noticed, as a point in its favor, that its nave does not exhibit the *retrécissement* or effect of narrowing in of the vertical lines, which he has observed in the Cathedral of Cologne (Vol. I, p. 233). He suggests that this is due to the horizontal line of the sculptured stringcourse which breaks the perpendicular lines at the level of the Amiens triforium. When he published this remark M. Durand was not aware of the amount of widening in the Amiens nave and it appears to me more reasonable to presume that its admitted superiority to the nave at Cologne may be explained by this widening.

As regards engineering questions, M. Favry's opinion was given without hesitation, that inclinations in straight lines, beginning at the arcade capitals, could not be caused by vaulting thrust from the upper nave, for the reason that the weight of the aisle vaults and their counter thrust towards the nave, so added to the resistance to thrust from the nave vaulting below the triforium, that a diminished inclination below that level would be inevitable.

It may be added here that no engineering expert who has seen the debated enlargements has ventured the opinion that a nave vaulting thrust could have caused even a diminishing inclination below the level of the triforium, either at Rheims or at Amiens.

Peculiar interest attaches to the experience with M. Favry, because his conversion was so entirely based on photographic evidence. Notwithstanding the fact that the little sacristy where we met, is inside the cathedral, M. Favry did not examine the nave on this occasion. We have never been in the Amiens nave in company. In fact, it would have been useless for M. Favry to examine the nave, and after he had seen the photographs he knew that it was useless, having learned from them facts which he had never seen in the church. In the lofty nave of Amiens it is impossible to realize the true facts as regards the vertical lines. The illusion due to perspective convergence of the verticals causes them to appear perpendicular.

There is an illusion of an opposite character which is produced by the diagonal vaulting ribs of the nave or choir, as already explained for the aisles, at the points where they unite, in vision, with the lines of the transept crossing arches, as seen from the nave. This illusion tends to exaggerate the actual divergence of the crossing piers and to create an effect of curvature near the vaulting where none really exists. These illusions operate variously, according to the position of the spectator and according to the special point on which the eye is centered. They are also undoubtedly affected by the personal equation, by the imagination, and by the personal predisposition or prejudice in favor of a preconceived or fixed idea.

As between Amiens and Rheims, there are several reasons for preferring the latter cathedral for test observations. As previously mentioned, the plumb-lines which are furnished by the chandelier chains at Rheims are already in position and they are numerous. The greater solidity and massiveness of the construction at Rheims are also notorious. Professor F. M. Simpson says of this cathedral: "Of the different cathedrals in France, Rheims is probably the best built. Street eulogizes the construction as perfect and says there is not a crack in the building." *

Allowances for slight accidental movements must be made at Amiens,† but as no similar accidents have occurred at Rheims, the coincidences as to essential facts at Amiens are convincing evidence that the same system was employed in both cathedrals.

The curvature in plan in the clerestory parapets at Rheims (fig. 8) is also more pronounced and more easily accessible than at Amiens.

This is the next feature to be considered. In Rheims Cathedral the tower piers next the entrance incline only about 4 inches to a side and the crossing piers are perpendicular; whereas the inclinations at the centre of the nave are about 8 inches to a side.‡ Since the piers are perpendicular and are in strictly rectilinear arrangement, it follows, from the changes of inclination in the vaulting-shafts above the piers, which increase toward the centre of each side of the nave, that the clerestory walls must be curvilinear in plan.

Fig. 8 illustrates this curvature. The view shows a straight line stretched along the south clerestory parapet. The surveyor's rod, which is laid down at the point of greatest deflection, marks an outward curve of 10 inches. A similar photograph has been made of the north clerestory parapet, which shows a similar curve of the same amount. These curves were already

* *History of Architectural Development*, Vol. II, p. 275.

† Full consideration of this subject will be found in the *Journal of the R. I. B. A.*, "Amiens Cathedral and Mr. Bilson's Rejoinder," Sept. 25, 1909.

‡ As measured by photography the actual widening is about 10 inches to a side at the centre of the nave, but about 2 inches of this must be credited, not to inclination, but to stepping back of the vaulting-shafts directly above the arcade capitals.

known as constructive, to the architect in charge of repairs, and to his assistant, at the time of my visit, but as the interior deflections had not been noticed, it was naturally not known that these deflections were the cause of the curves. All visitors who ascend the towers at Rheims visit these parapets and it is the habit of the guide to mention and point out these curves. One has only to look at the surveyor's rod in the photograph to realize that the clerestory wall, the parapet, the vaulting-shafts, and the buttresses, have not been pushed outward 10 inches on both sides of the cathedral, by accident. The resulting serious fractures, or the traces of their repair, along this constantly frequented parapet, would have been thoroughly well known, in that case, to M. Margotin and to M. Martin, and we shall not forget what Prof. Simpson has said of the absence of cracks in this cathedral.

In Amiens Cathedral corresponding curves in plan, of less amount, had never been observed until I had them photographed. They are due to the fact that the tower piers next the entrance, are perpendicular up to the vaulting, that the crossing piers lean out only 5 inches to a side, and that the nave piers are perpendicular and in straight alignment, whereas the vaulting-shafts of the nave incline outward toward the centre of the nave, to a maximum of 10 inches on the north side and 6½ inches on the south side.*

The estimates for widening at Rheims and at Amiens have been mentioned as computed to the capitals of the shafts at the springing of the vaulting. In order to appreciate all the implications which are involved in these measurements it should be stated that the related surface inclinations, which begin in the arcade spandrels, continue, both at Rheims and at Amiens, in straight lines to the tops of the clerestory windows. Thus at Rheims the maximum inclinations of 8 inches, in the surfaces which are on the level of the capitals of the vaulting-shafts, become 14 inches at the tops of the clerestory windows. Along the transverse horizontal joints, where the wall cells of the vaulting unite, this would involve fissures amounting to 28 inches, if the widening at Rheims were due to accident. Will anyone claim, that such fissures have existed in a vaulting which is celebrated for the absence of cracks, and without the knowledge of the architect in charge of repairs? At Amiens the widening is a third greater at the tops of the clerestory windows than it is at the vaulting-shaft capitals. Thus, along the nearly horizontal transverse joints of the nave vaulting, which unite the opposite window arches, and which only rise 20 inches above the horizontal level, in a clear width of 40 feet 10 inches, the fissures would have amounted to about 22 inches at the centre of the nave, if accident had caused the widening. We are assured, however, by M. Durand, the highest authority on the history of the church that the repairs of the nave vaulting at Amiens have been "comparatively slight."

It is evident that lowering at the crown of the transverse arches and consequent distortion of the vaulting ribs must always be the consequence of widening, when caused by thrust. Not the slightest indication of such distortion is found at Rheims. I have published an elaborate description and consideration of the slight distortions at Amiens, together with telephoto photograph, in the *Journal of the R. I. B. A.**

Although the width of the fissures, as called for by the theory of accident, would be very considerable, either at Amiens or in Rheims Cathedral, it should still be observed that the amount of slope, as related to the diameter of the piers and shafts, is not such as to endanger the equilibrium of the building, if that slope be constructive, although it has constantly been assumed by those who discredit the existence of constructive widenings, that this would be the case. Thus, the extreme slope at Amiens, which is 10 inches, is only one-eighth part of the diameter of the piers, which is 7 feet, without including the mouldings. The extreme slope at Rheims is also only one-eighth of the diameter of the piers, which is 9 feet 1½ inches, without including base mouldings. (Although the diameter of the piers is greater at Rheims, the ratio to slope remains the same on account of the lower height of the vaulting-shafts and the much greater relative height above the capitals of the vaulting-shafts, to the tops of the clerestory windows.) It is apparent that the center of gravity of the piers would not be affected by such slopes and that the equilibrium of the building would not be endangered by them. In other words, the slopes, as found, would call for serious and non-existent dilapidations, if they were accidental, but they would not remotely endanger the building if they were constructed. On the contrary, it may be suggested that they promoted the security of the construction before the vaulting was built. It is well known that the flying buttresses, which had to be first completed, tended to thrust the clerestory walls inward before the vaulting was finished and it may be reasonably held that a slight outward slope of the piers against this pressure of the flying buttresses was a highly desirable expedient.

In the case of St. Remi at Rheims (fig. 7) the ancient nave vaulting has long since been taken down and is now replaced by a plaster vault, but we have ample evidence from the still extant vaults of the aisles and the wide vaulted galleries above them, that no vaulting thrust could have operated in straight lines down to the capitals of the piers, against the weight and counter-thrust of these two vaults.

The Cathedral of Laon, although of larger size, has similar proportions, as regards the low height of the piers, the great height of the vaulting-shafts, and the wide vaulted galleries above the vaulted aisles. Thus Fig. 7 represents not only St. Remi, but also the type of widening at Laon, where the nave vault is in good order. In a Brooklyn Museum picture of the north gallery at Laon the plumb-line marks the inner sides of the nave vaulting-shafts as *leaning inwards, against the thrust of the gallery vault,* 1½ inches in a line 8 feet long. These inclinations are uniform throughout this gallery.

One of the most remarkable illustrations of the series

* See p. 737, *Journal of the R. I. B. A.* for Sept. 25, 1909. The slight allowances for thrust are confined to the second pair of vaulting-shafts from the entrance (1¾ inches north, 1¼ inches south). The measures quoted in the text are those for the third and fourth pairs of vaulting-shafts, exactly in the center of the nave.

* Sept. 25, 1909.

(*Continued on page* 124.)

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CONTENTS

THAT progress is not always in the direction of greater artistic development is a lamentable fact only too apparent. Indeed, it sometimes seems fairly questionable whether the replacement of some of our historic landmarks by modern buildings of vast proportions and immense value is in reality progress at all, in the broader sense. An increase in the material wealth of any country must be accompanied by a corresponding or greater increase in its artistic wealth if development of the highest order is to be attained. Unfortunately, this fact does not seem to have been generally realized in the past. Some of the most notable buildings erected in this country during the period of its early history apparently furnished no inspiration for the designers of their modern successors. Within the past five years, for example, New York has lost a number of her treasured landmarks, among them buildings which were formerly pointed to with pride by architects and artists of the present day, as an evidence not only of the ability and skill of their predecessors, but also as indicating to a considerable degree the culture and refinement of the preceding generation. It is a matter of deep regret that in few instances have the buildings reared on their sites approached in character those which they have supplanted. Perhaps the size or purpose for which the new buildings were reared rendered them impossible of execution along the most pleasing lines. It might, however, have been possible in the case of at least one or two which we have in mind to have preserved some of the features of the former buildings to remind us of the beautiful even though less pretentious structures which have now passed into history.

THE burning of interior furnishings and wood trim of a building in this city has again been made the occasion for sensational articles in a certain portion of the popular press. Writers in these publications dwell at length upon the character and construction of buildings in general and strongly suggest that the use of the word "fireproof" as a descriptive term in connection with any of them is a misnomer. The particular conflagration which has called forth this latest discussion of the perennial question, "Are any buildings really proof against fire?" occurred in one of the apartment buildings of the better class recently erected in this city. As usual the flames found fuel in the furnishings, wood trim and floors, so that sufficient heat was generated to break the glass in the windows and do some slight injury (principally discoloration) to the materials of construction used in the exterior. Structurally the building was not injured in the slightest. It seems an unfortunate trait of humanity that prompts an army of self-appointed experts to come forward through the medium of the press with statements as mischievous as they are inaccurate. The erroneous impression thus created in the public mind tends to prevent the adoption of the better forms of construction, as they are made to appear valueless as a protection for life or property from fire. If the facts concerning the results of fires that have occurred in well-constructed buildings of the fireproof type could be clearly and accurately set forth in the public press, it might perhaps, in a measure, counteract the effect of the sensational accounts which have appeared in some of the metropolitan dailies and been copied into the papers of other cities throughout the country. The entire question merits careful consideration, but in taking it up two facts must be clearly kept in mind. First, that inflammable hangings and furnishings will burn even when enclosed in a fireproof building. Second, that a structure containing large quantities of well-seasoned wood trim with wood floors and wood doors is far from fireproof, even though its walls, partitions and supporting members will not burn.

To those who have knowledge of the actual conditions there have been no surprises, disappointments or revelations of any kind furnished by accidental conflagrations during recent years.

THE action taken by the New York Chapter of the American Institute of Architects protesting against the erection of the new County Court House in City Hall Park appears most timely and commendable. It is unquestionably to the interest of this city and the entire country that no further encroachment on this most beautiful and historic park be permitted. It appears most deplorable that attempts to pervert the use of some of this city's parks and breathing spots are made with such frequency. Practically every year brings forth some project that would deprive the people of a portion of the all-too-little space allotted to parks. We trust this latest plan, which we feel is ill-considered and unwise even beyond its predecessors, will not prevail.

(*Continued from page 122.*)

of 1907, is Plate 11, showing the widening of 6 inches in the central light of the choir window at Laon, under conditions which preclude every suggestion of accidental movement. This widening corresponds to the construction of the nave and choir, aside from the fact that the inclinations of the central window begin at the sill and that they begin at the capitals in the nave and choir, as in Fig. 7, of St. Remi.

If it may be allowed to offer a summary argument, including all the examples illustrated, before closing this paper, this argument would be stated in the form of a query, as follows: *If two types of rectilinear widening exist, as is now proven to be the case, and if they are both due to accident, why should not one and the same church exhibit both types of widening?* Still farther, why should not parts of one church begin to incline at the pavement, and other parts begin to incline at the capitals, or at corresponding levels, and still other parts begin to incline midway between these points below the capitals, and still other parts begin to incline above the capitals at various levels? Why should the rectilinear inclinations in the churches which have been described *only be of two kinds,* and especially may this question be asked, considering that these two kinds of inclination have not been found in the same nave of one given church?

In other words, the uniformity of the presence of one kind of phenomena in the corresponding parts of one church, and in so many different churches, is incompatible with the theory of accident, and especially so, because there are known to be two varying phases in which the rectilinear inclinations appear, when different churches are in question.

This argument does not imply that variations are not found in the rectilinear pitch, for the contrary holds, for example, in Rheims Cathedral and at Amiens, and here again the query rises: *why should variations of pitch all start from one level,* if they are due to accident? This appears highly improbable. On the other hand, it could be readily argued that the enormous weight of the central spire, which was planned at Rheims, rendered it advisable not to incline the crossing piers and that variations of pitch, in inclinations gradually diminishing from the center of the nave, would have been the natural alternative.*

The argument just stated is confined to the illustrated churches of this paper. It does not imply that constructive vertical curves are not found in mediaeval churches. The contrary is well known to be my opinion and the following paper will include this subject.

My own observations include many churches not mentioned in this paper which is confined, as regards illustration, to carefully observed rectilinear instances.

It will have been gathered from my last paper that an extremely influential and highly estimable body of antiquarians have concurred in the opinion that there is not a single instance of the widening refinement in Europe, and that all the "supposed" discoveries which I have quoted are solely the result of physical accident. Under such circumstances it is desirable not to appear as an absolutely solitary observer. Thus, aside from the certificates quoted in this paper, the observations of other authorities may be quoted in the next and last.

* These variations of pitch at Rheims have been measured by Professor Charles S. Hastings, in the article quoted in this paper.

NOTED GLOBE ROOM MAY COME TO U. S.

Negotiations are proceeding on behalf of an American purchaser to transfer bodily to the United States the famous Globe room of the Reindeer Inn in Banbury.

The Globe room is one of the places of pilgrimage visited by thousands of American tourists and others from all parts of the world yearly. Experts declare it the finest specimen of Jacobean architecture in the country. The authorities of the South Kensington Museum recently had a plaster cast taken of the ceiling, and this is now among the nation's specimens of historic art as an example of the finest work of the period.

The Reindeer Inn is between three and four centuries old. The date on the gates is 1570.

AN ENGLISH ARCHITECT'S PLEA FOR MODERN DESIGNING.

Raymond Unwin, an English architect, urges that as the planning of a town must, by the very nature of things, be a more or less complete expression of its life, such expression should be sincere and direct.

He holds, as an example, that it would be impossible to reproduce and most unwise to attempt to copy the picturesqueness which resulted from the natural and apparently unconscious growth of the mediæval towns or the formal magnificence of the great cities of ancient civilizations, but the principles upon which these builders worked are undying, and from them may be developed new forms of beauty that express quite as spontaneously the conditions of modern life.

This beauty must come when we realize that it is a part of life and that all sincere living inevitably finds such expression of itself, but its coming may be hastened by the acknowledgment of our lack of the quality that produces it and by honest efforts to build as well as we may according to our present needs.

Mr. Unwin says the designer's most important duty is to study his town, his site, the people, and their requirements before attempting to put his own ideas into effect. "There is no need to fear," he continues, "that such a course will lead to commonplace designs that will check the flights of fancy and subordinate the main effect of trivial inconvenience. In this work we cannot rightly say that practical considerations come before the artistic or the artistic before the practical; they are independent and must be worked together.

"But there is this difference between them: The practical considerations are often fixed while the artistic expression may take varying form. Drainage will not run uphill to suit the prettiest plan, nor will people, to please the most imperious designs, go where they do not want to go or abstain from going where they must needs go, and from taking generally the shortest route to get there. Lines of drainage and of traffic may be modified, but only within narrow limits, and the planner who pits the form of his plan against the forces which define these limits will but wreck his scheme."

PLATE I

ST. ALPIN, CHÂLONS THE WIDENING REFINEMENT

Plumblines on the piers which show them to be inclined in straight lines from the pavement up. Two oblong disks (8″ x 10″) on the plane of measurement near the piers. Upright surveyor's rod, 6 feet high, near the center of the picture, disk 5½ inches diameter. Similar inclinations throughout the nave.

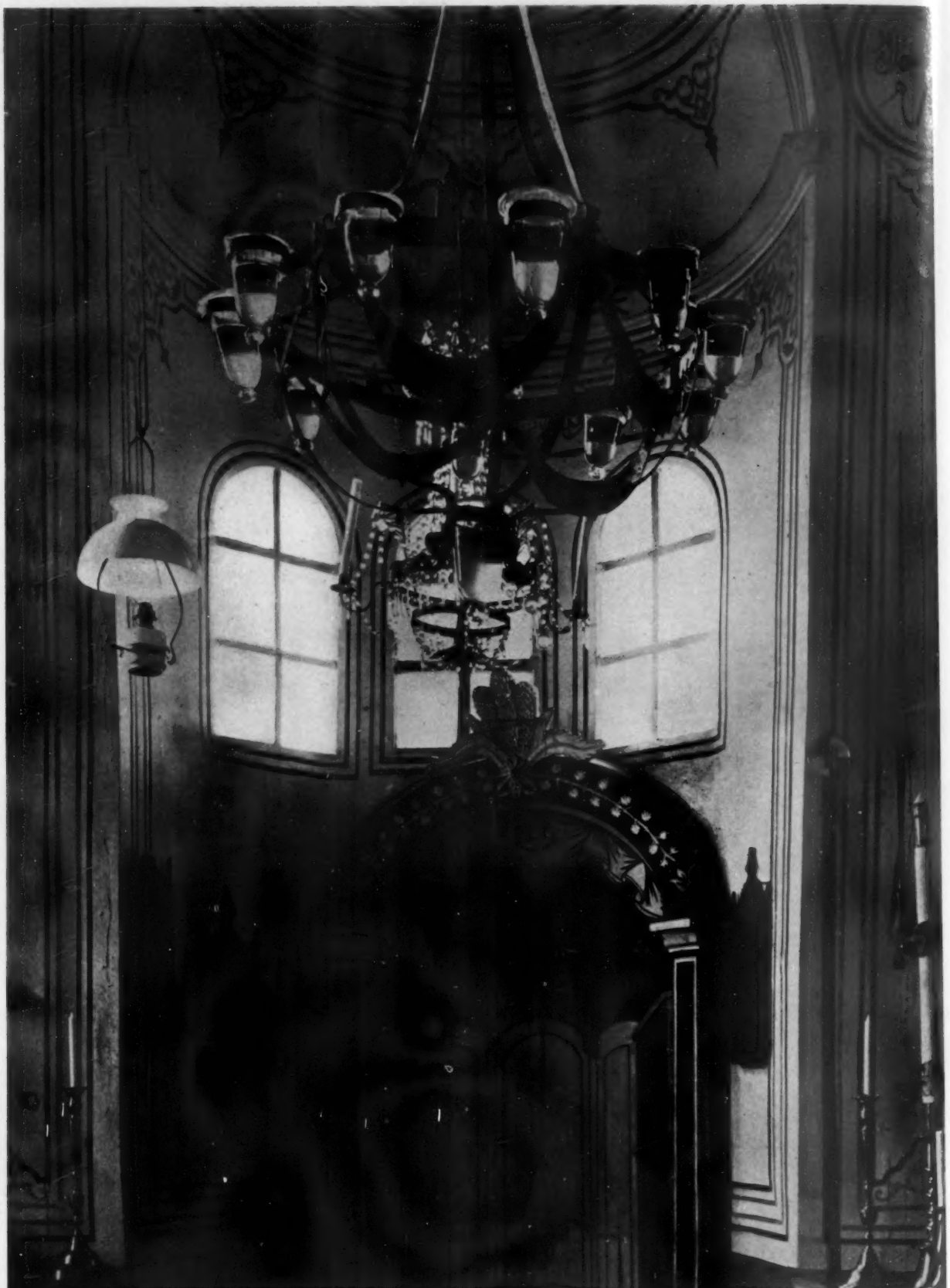

PLATE 2

APSE OF A BYZANTINE CHURCH AT CONSTANTINOPLE, NOW THE BALABAN AGA MESJID MOSQUE

Short plumbline (to establish the perpendicular) suspended from nail on the right side near the outer candle. Surveyor's rod, 6 feet high (disk 5½″ diameter). Widening of 5 inches in 12 feet.

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PLATE 3

THE CHOIR OF ST. LOUP CHÂLONS

Plumblines on the exterior sides of the piers (strengthened). Surveyor's disks (8" x 10") at the outer sides of the piers, near their bases. Inclinations are 4 inches to a side, in a height of 23 feet 4 inches. Similar inclinations throughout the nave.

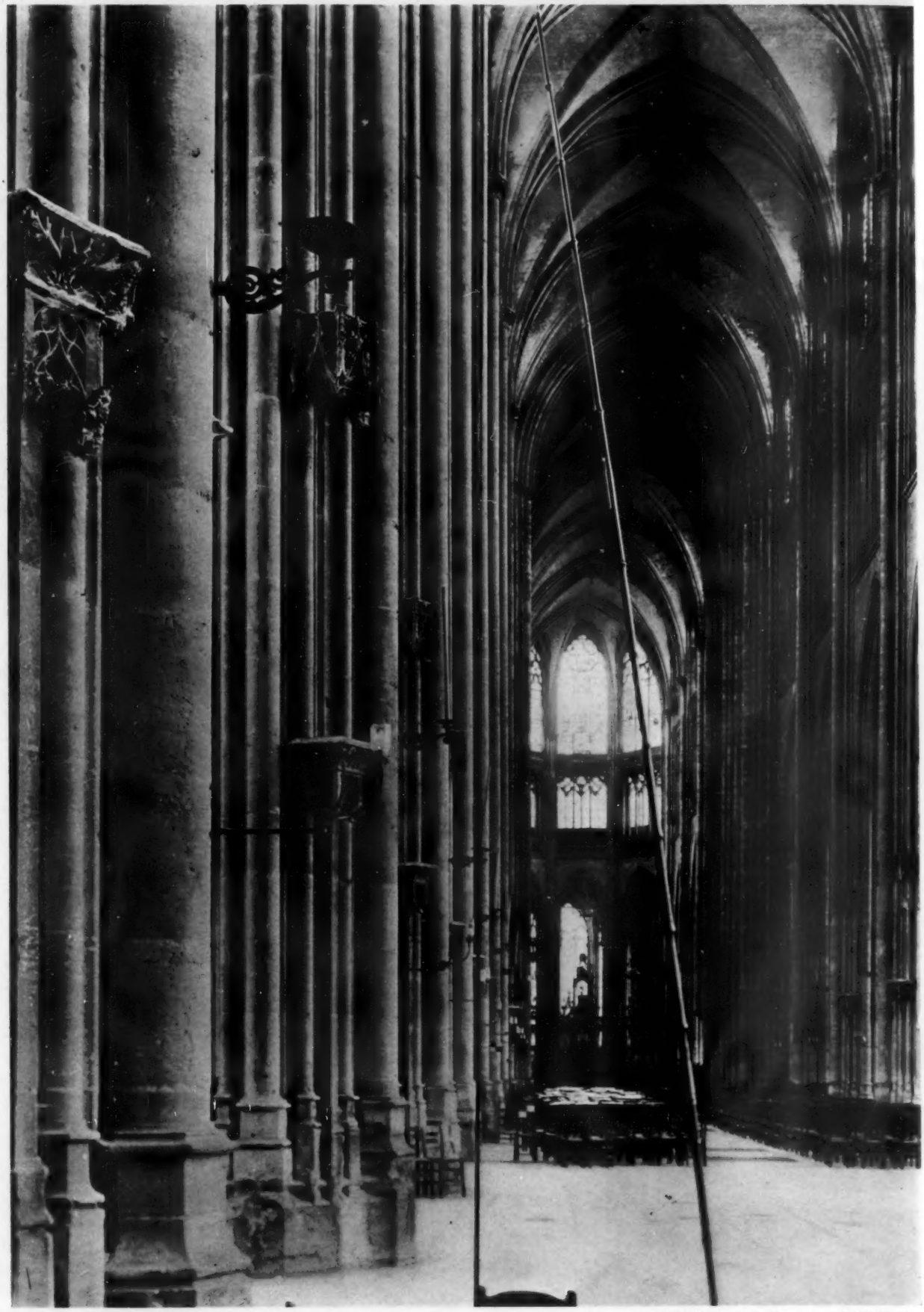
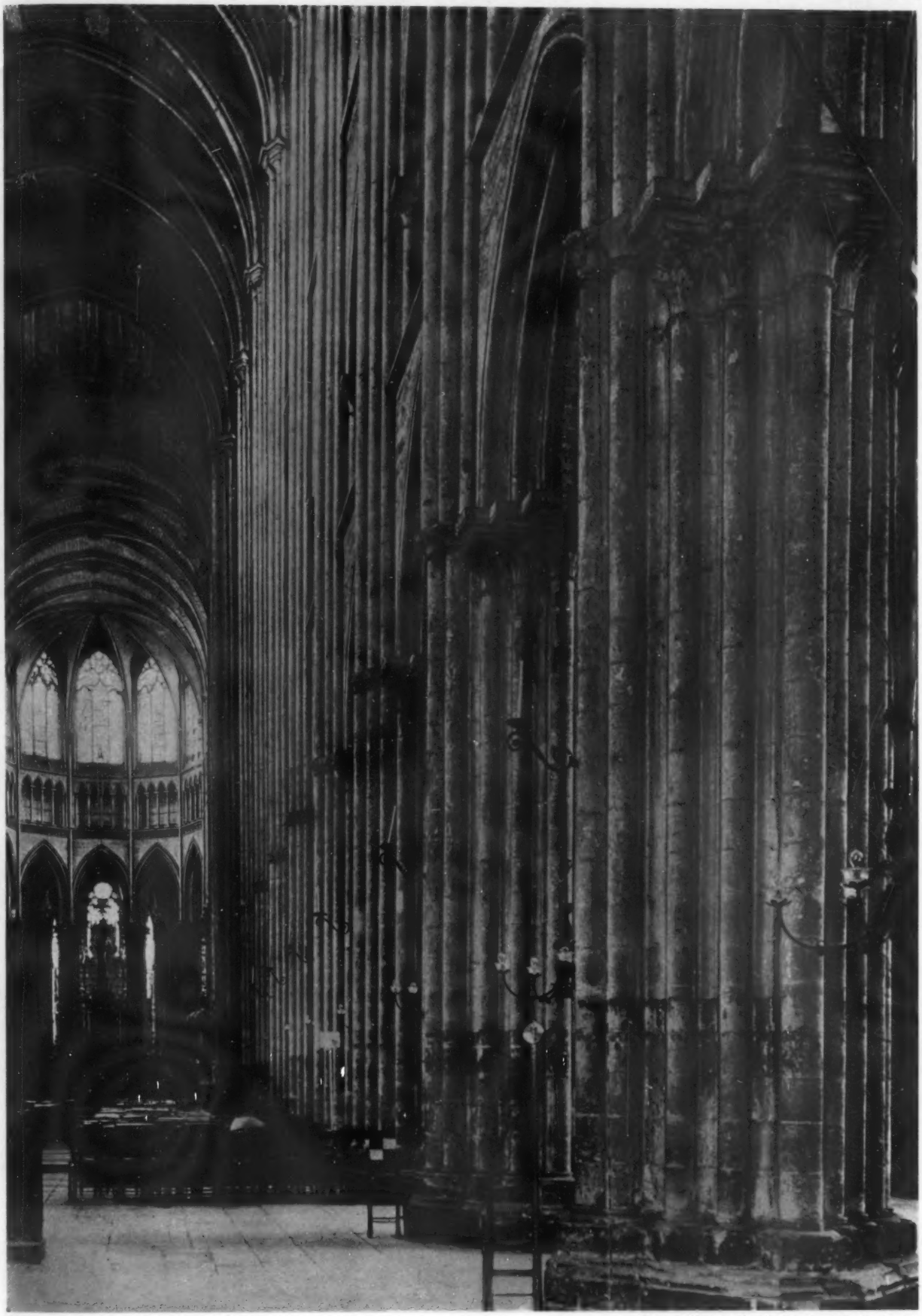


PLATE 4

THE CHURCH OF ST. OUEN ROUEN

Plumbline suspended from a bamboo pole near the lens. Three surveyor's disks on different planes of measurement. Inclination of 6½-7 inches, in a height of about 80 feet. The plumbline, being out of focus toward the lower extremity, is strengthened.



CATHEDRAL OF ROUEN PLATE 5 THE NAVE, NORTH SIDE

Plumbline suspended from a bamboo pole near the lens. The inclinations may also be tested by the chandelier pipes. Three surveyor's disks, on different planes of measurement. Inclination of first pier on the right is 3⅝ inches to arcade capital, in a height of 18 feet 9 inches, not including base. Inclination for entire height is about 12 inches a side. The plumbline, being out of focus toward the lower extremity, is marked in by dashes.

PLATE 6

THE CATHEDRAL OF ROUEN — SOUTH AISLE, LOOKING EAST

Plumb from bamboo pole on aisle responds of transverse chapel walls. Surveyor's rod on the plane of measurement. Inclination of respond is 8 3/4 inches in 38 feet 9 inches. The plumbline, being out of focus toward the lower extremity, is strengthened.

PLATE 7

RHEIMS CATHEDRAL — SOUTH AISLE, LOOKING EAST

Plumbline suspended from bamboo pole near the lens. The inclinations of the responds average about 2 1/2 inches in a height of 30 feet 6 inches, not including steps or base. The inclination begins above the fourth course of masonry.

PLATE 8

AMIENS CATHEDRAL — THE WIDENING REFINEMENT

Two plumblines. Surveyor's rod near the farther line. Inclinations about 3 inches. Height of responds about 43 feet. The nearer plumbline is strengthened by dashes. These inclinations are uniform for both aisles of the nave, and also for both aisles of the choir.

PLATE 9

RHEIMS CATHEDRAL — THE WIDENING REFINEMENT

Several plumblines. Two are strengthened by dotted lines. The one on the left is a surveyor's line, suspended from the triforium. These plumblines show the piers to be perpendicular to the arcade caps, with the recessions, in straight lines, of the vaulting-shafts, beginning there. Inclinations at the centre of the nave are about 8 inches, and the shafts step back about 2 inches at the arcade capitals.

PLATE 10

AMIENS CATHEDRAL — NORTH AISLE, LOOKING EAST

Cable plumbline on the south (left) side, showing the piers to be closely perpendicular up to the arcade caps, with recessions in straight lines of the vaulting-shafts beginning there. These inclinations average about 6 1/2 inches on the south side, with exception of the pier next the crossing, which inclines 5 inches.

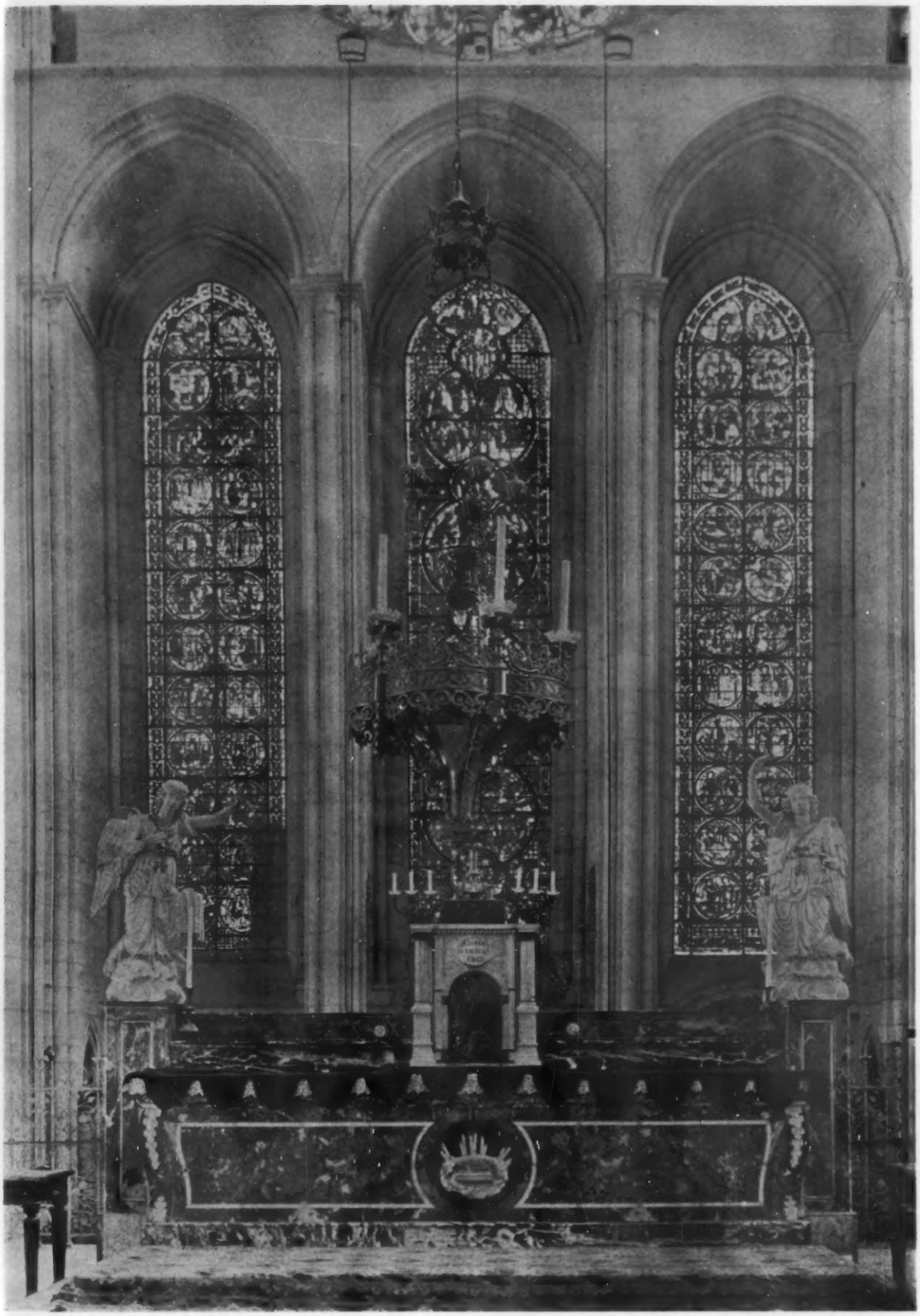


PLATE 11

LAON CATHEDRAL THE CHOIR WINDOW

Three plumblines. Fourth line on right outside the picture. Surveyor's disk on the chair above the central light. Two other disks at the extreme right and left, near the base of the picture. The central light widens 6 inches.

PLATE 12

ST. MARK'S, VENICE — THE MAIN DOORWAY

Surveyor's rod on the left side. Widening from 10 to 11 inches. Plumbline on the right to establish perpendicular, but not clearly visible.