Clarifying confusions surrounding the use of oblique and parallel projections reveal the unfulfilled promise of axonometry in twentieth-century architecture.

Revolutions in space: parallel projections in the early modern era

Hilary Bryon

There is ambiguity and confusion concerning the nomenclature of parallel projection. Today, such representations are often broadly identified as axonometrics. However, the actual history of parallel projection, delineated by oblique and axonometric projections, reveals inherent spatial differences. By clarifying the intrinsic demarcations between these two forms of parallel projection, one may bring into question anew the approaches and applications of parallel projection as an architectural form of representation in the twentieth and twenty-first centuries.

Parallel projection is a form of pictorial representation in which the projectors are parallel. Unlike perspective projection, in which the projectors meet at a fixed point in space, parallel projectors are said to meet at infinity. Oblique and axonometric projections are differentiated by the directions of their parallel projectors. Oblique projection is delineated by projectors oblique to the plane of projection, whereas the orthographic axonometric projection is defined by projectors perpendicular to the plane of projection. Axonometric projection is differentiated relative to its angles of rotation to the picture plane. When all three axes are rotated so that each is equally inclined to the plane of projection, the axonometric projection is isometric; all three axes are foreshortened and scaled equally. Dimetric projections have axes rotated so that two are equally foreshortened and thus scaled by the same factor, and trimetric projections have three differently inclined axes. One of the traits that overtly divides oblique from axonometric projection is that oblique projection has both two-dimensional and three-dimensional space attributes. Oblique projection presents an aspect of two-dimensional geometric purity stemming from the fact that one plane of the object lies parallel to the picture plane. Depth is indicated in an act of oblique extrusion – from the plan in the case of military projections and from the elevation, or section, in cavalier projections. The visual cue is that the orthogonal geometry of the plan, elevation, or section is undistorted, as it lies parallel to the picture plane.

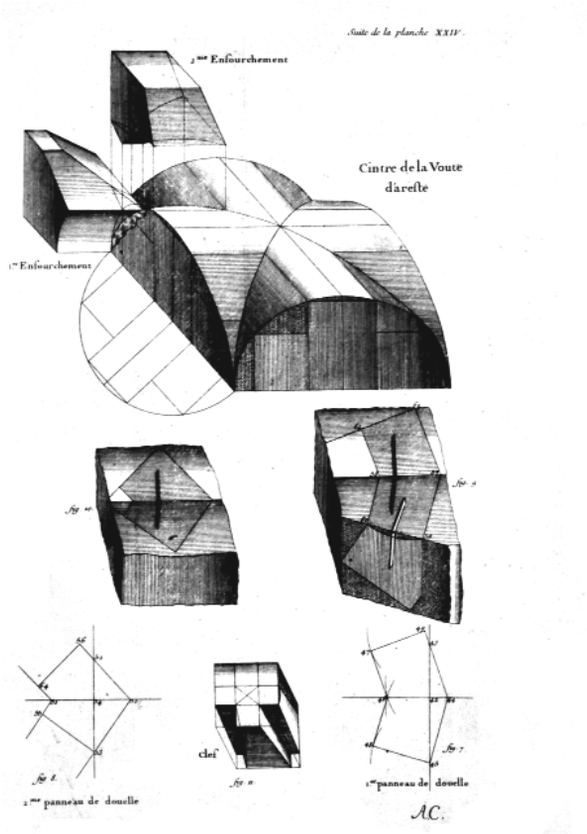
Oblique projections

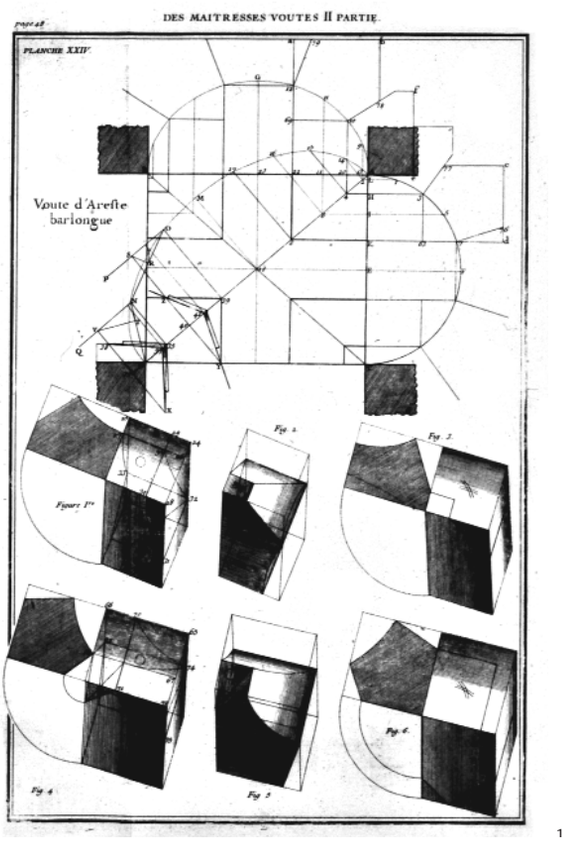
The history of oblique projection can be traced from the use of profiles. A profile or elevation exhibits primary or essential characteristics using shape and outline. Various cultures, such as the Greek Attic, North American Fremont, and Chinese Sung, have shared such representational techniques. The appearance of depth can be implied via parallel lines of shadowing, or the simple shifting or offsetting of the image in the orthographic plane. These intuitive proto-oblique systems have a much longer history of use than perspective projection. Indeed, the architect Massimo Scolari speculates that the 'hegemony of the perspective has prevented consideration of other equally important modes of representation', such as oblique and axonometric projections.[1]

Regarding pictorial forms of representation, perspective has come to dominate all other systems. It was only in 1706 that oblique projection, called at the time cavalier perspective, was geometrically and rationally theorised as a representational technique by Louis Bretez in *La perspective pratique de l'architecture*. Bretez juxtaposes perspectival and oblique techniques, but did not supplement his geometric construction of the latter with an illustration. Yet, one can discern the critical difference established between the oblique 'cavalier perspective' and the conic perspective. The term cavalier perspective stems from the military utility of the drawing system at the time. It is a distant view comparable to that seen by a soldier atop his horse. The oblique projection's vanishing lines extend to infinity, parallel; thus, offering the advantage of measurability. Whereas the focal point of a conic perspective necessarily distorts the technical dimension of an object, the cavalier perspective is more faithful to the *techne* of the object while still offering an image to the eye. The technical dimension of oblique projection continued to evolve throughout the eighteenth century.

By 1728 Jean Baptiste de la Rue made recurring use of geometrically accurate oblique projections. His *Traité de la coupe des pierres* is a treatise on stereotomy. Stereotomy is the art or technique of cutting solids

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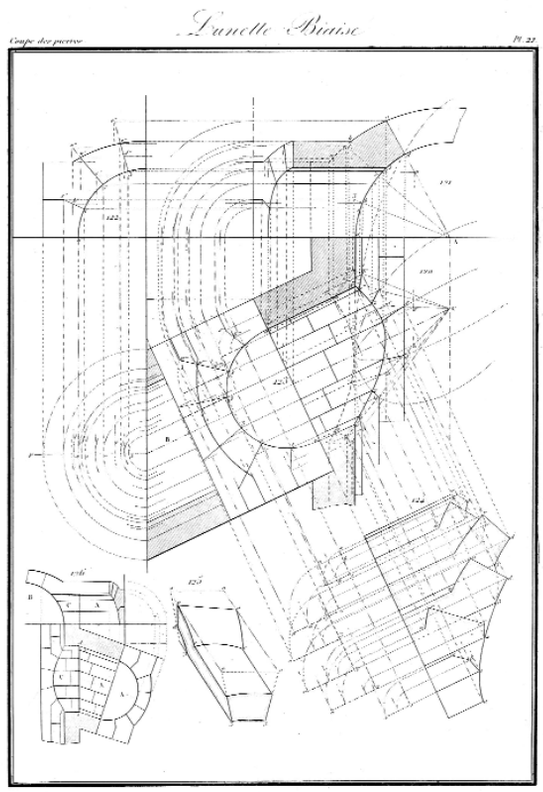


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especially as employed in stonecutting, but also in woodcutting and joinery. His stereotomical method was qualified as an 'easy and abridged method to self-perfection in this science'.[2] De la Rue exhibits the complex constructive geometry of different vault types; the stereotomic constructions are made easy to comprehend by the use of juxtaposed oblique projections *[1]*. Individual voussoirs are detailed in progressive stages of construction. De la Rue's method exploits the cavalier perspective's explicit orthogonal face and oblique parallelism to document the subtractive development of the individual stone elements. Furthermore, the face parallel to the projection plane is often at the same scale as the geometrical plan. The representation of the depth of the two-dimensional oblique extrusions is clearly awkward; while accurate by measure, oblique projection is visually disruptive when the projectors are not foreshortened and the oblique projectors cannot be reduced if one wishes to preserve the same scale of measure with the orthogonal plane.

French descriptive geometry

In France, the development of oblique projection was largely hindered by the adoption of another drawing system, descriptive geometry. Descriptive geometry is an abstract graphic technique using geometric traces and planar projections to represent three-dimensional objects on paper. Mathematician Gaspard Monge developed and systematised the technique in the 1770s and 1780s, however the process was protected for military use and designated a state secret. It was not until 1795 that Monge was able to publish his graphical



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communication system in *Géométrie Descriptive*. With great national pride, this system was adopted by the French. Descriptive Geometry was promoted at the Ecole Polytechnique as the modern engineer's most appropriate instrument of communication, an efficient and accurate graphic language. While Monge's rationalised method can be a bit complicated, it was intended to facilitate accurate

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and truthful two-dimensional command and representation of three-dimensional objects; it is based on fundamental geometric operations. The graphic exercises associated with descriptive geometry visually illustrate these tenets and operations as the methods were applied to the technique of cutting solids [2]. Efficiency in achieving the bias cut volume, as seen in portals, arches, and especially tunnels, came to be the ultimate geometric challenge to the nineteenth century's stereotomist engineers.

Throughout the century, the drawing system remained an extensive part of the Ecole Polytechnique curriculum. Development of parallel projection was clearly impeded by the powerful legacy of Monge's *Géométrie Descriptive*. Jules De la Gournerie, professor of geometry at the Ecole Polytechnique from 1850 to 1863, reflected:

> *'Monge and his disciples wrote nothing on cavalier perspective, but in effect, they dismissed it* [...] *The rejection of cavalier perspective seems to me to be a natural consequence of Monge's doctrine.'*[3]

Ironically, the material sense became lost in descriptive geometry's graphic processes. One can discern this when juxtaposing the mass and process of stone construction made manifest through oblique projection in De la Rue's demonstrations and the light and ethereal geometric traces as evidenced in Adhémar's graphic delineations via descriptive geometry. By the second half of the nineteenth century, descriptive geometry at the Ecole Polytechnique had become an impractical, time consuming geometrical exercise. Ultimately, the Industrial Revolution was introducing new materials which did not require complex stereotomical operations; stone was being replaced by concrete. Coincident developments with cast iron, and finally steel, would lead the British to question graphic techniques for the new technology.

English isometry

English Empiricism manifested a new drawing type. Isometrical perspective was codified by William Farish in a paper read before and published by the Cambridge Philosophical Society in 1820 and 1822. Farish was Jacksonian professor of natural philosophy at Cambridge between 1813 and 1837. The principal part of his course, On the Construction of Machines, was an offshoot of previous courses on experimental philosophy in which the theory and construction of mechanisms had been used to demonstrate the principles of Newtonian mechanics.

Farish's drawing system developed in tandem with a modelling system: a kit-of-parts by which to demonstrate mechanical principles [3, 'Fig. 9']. The drawing type developed in order to record these temporary constructions in three-view drawings, as plans, sections, and elevations did not allow the object to be understood as a three-dimensional entity in space. Farish observed that common perspective distorts the reality of the object since parallel lines are not represented as parallel and there is no measurable scale.

Farish established his process via a cube [3, 'Fig. 3']. He states that isometric literally means equal measure and all three principal faces make equal angles with the picture plane and so consequently all have the same scale.[4] The author acknowledges that isometric perspective is not a perspective, but corresponds to the function of a perspective by rendering a pictorial view. The eye of the artist is placed at an indefinite distance, rather than at a fixed point. Farish's assumed bird's-eye view also instils a sense of distance. Regardless of his expressive terminology, Farish understood isometrical perspective as a 'species of orthographic projection'; the projection is on a plane perpendicular to the diagonal of a cube.[5]

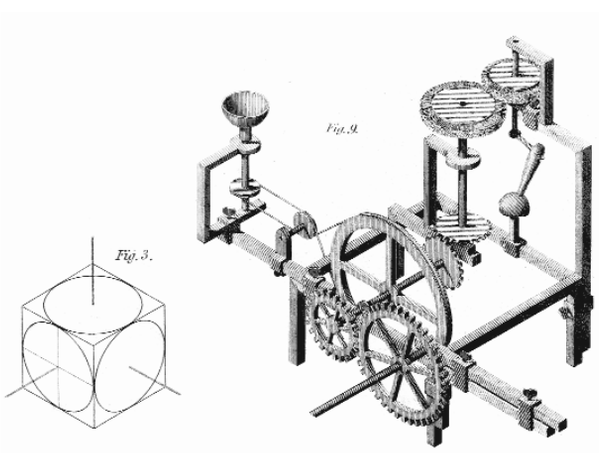
Farish's isometrical method is not geometric or mathematic, but practical. The drawings are made with ease using three tools: a T-square rule; a specialised 60° sliding rule; and isometrical ellipse templates. Furthermore, while isometrical drawings are by nature proportional, Farish's renderings lack an assigned scale; the objects could be any size. The absence of measure draws attention to what must be considered the most important aspect of isometry to Farish: a relative, accurate, quickly produced picture of the assemblage of the parts to a whole. Indication of a formal scale is not necessary when the parts are predetermined.

Outside of Cambridge, William Farish became renowned for his development, it being a new form of representation particularly appropriate to the emerging machine age and its technological imperatives. Isometry was quickly picked up and elaborated upon by fellow Britons. Several treatises

1 De la Rue demonstrates the geometry and carving of individual *voussoirs* in successive states of construction for a groined vault. The face parallel to the projection plane is at the same scale as the geometrical plan and the oblique projectors are not reduced. J. B. de la Rue, *Traité de la coupe des pierres. Seconde Partie: Des Maîtresses Voûtes* (Paris, 1764), Plate 24

2 A descriptive geometry *épure* with oblique projection detail. J. A. Adhémar, *Traité de la coupe des pierres* (Paris, 1858), Plate 21

3 Fig. 3: the isometric cube; fig. 9: Farish's kit-of-parts assembly. W. Farish, 'On Isometrical Perspective', *Transactions of the Cambridge Philosophical Society*, 1 (1822), figs. 3, 9



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investigated the method, including those by Joseph Jopling and Thomas Sopwith.

Like Farish, Jopling illustrated the basis of the isometric perspective via the representation of a cube. Jopling however used the cube to define the process. Indeed, the cube can be imagined to 'contain within it the whole of the model of any object intended to be represented'.[6] The treatise follows the imagined isometric, cubic mass as it undergoes cuts, first by perpendicular and parallel planes, then angled planes, and finally by curved lines, to unveil the complex 'encaged' object.[7] The method is conceived as a subtractive operation, not unlike the stereotomical constructions illustrated by De la Rue's oblique projections.

Jopling's method is surely empiric and pedantic, yet he nourished an imagined *rotational* view, as the boxed up object 'may be taken as an upper, under, or sideway view, and each may be taken as either internal or external; that is, in six different ways.'[8] Thus, while the assumed bird's-eye view of Farish was not brought into question, spatial possibilities of rotation were introduced to isometry. The object nonetheless is still rotated under the eye of a viewer – a bird's-eye view. The viewer does not move, rather the object is exhibited under the viewer's static gaze.

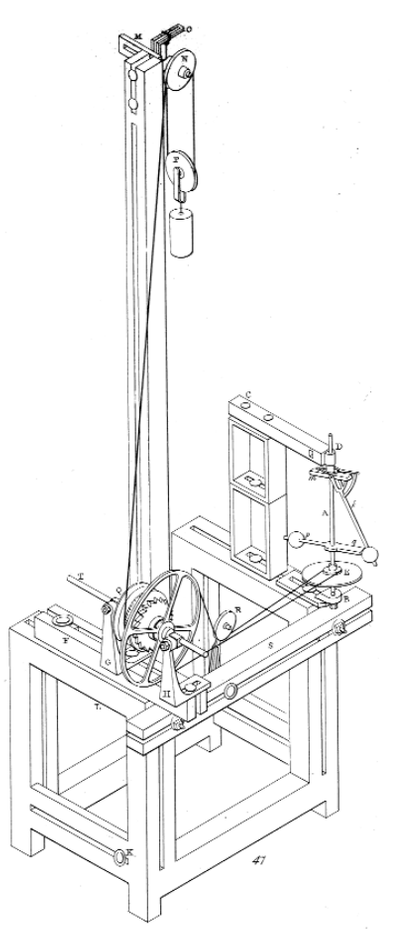
Thomas Sopwith's sizeable treatise on isometry appeared a year later in 1834. Sopwith generalised the advantages of the isometric:

> *'this mode of drawing fills up the space between the picture and the plan; between the picturesque beauty of the painter's canvas, and the formality of the designs of the mechanical draughtsman. Combining the accuracy of the plan with the force and clearness of the picture, it is evident that it may be rendered a most valuable and explanatory addition to the plans and drawings now commonly used.'*[9]

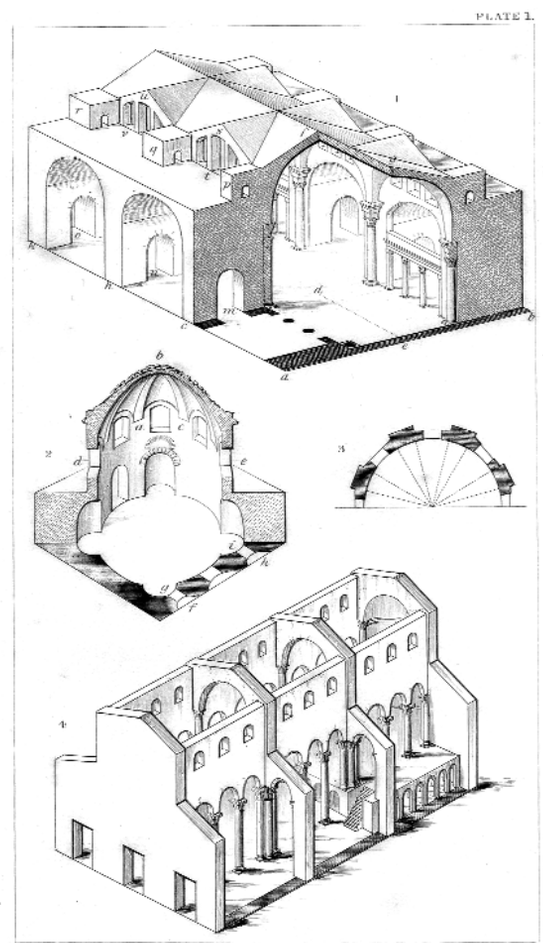
Regardless of Sopwith's account of the pictorial affiliation of isometry, he believed the term perspective was inaccurate and confusing. He adjusted the nomenclature to Isometrical Drawing.

Sopwith, a mining engineer from Newcastle-on-Tyne, offered refinements to Farish's method. Sopwith replaced the isometrical cube with isometrical lines and isometrical perspective with isometrical projection, but ultimately with the practical isometrical drawing. Sopwith's explanation of isometrical projection is theoretically grounded in descriptive geometry, yet his advocated method of producing an isometrical drawing is extremely prescriptive. In fact, Sopwith created and sold 'projecting and parallel ruler' sets which included a 'sheet of isometrical drawing paper' to facilitate the drawings' manufacture.[10] Sopwith's illustrations show the results of using his isometrical method; he represented many things including buildings, geological features, a landscape plan, a mine, a fossilised tree, a prison, and a large span arch. Sopwith's isometric drawings may be typified as illustrative pictures.

Sopwith juxtaposes an additional projection mode to isometric projection; he describes 'verti-horizontal' and 'verti-lateral' drawings. These are implicitly oblique *cavalier* projections, Sopwith



4 Willis's kit-of-parts assembly. R. Willis, *A System of Apparatus for the use of Lecturers and Experimenters in Mechanical Philosophy* (London, 1851), Plate 3, fig. 47



5 Fig. 1 has three differently inclined axes to the plane of projection while figs. 2, 3 are isometric. R. Willis, *Remarks on the Architecture of the Middle Ages, especially of Italy* (Cambridge, 1835), Plate 1

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wrote: 'they both exhibit an orthographical view or elevation of the front side'.[11] The verti-horizontal and verti-lateral differ only in the angle of the oblique projectors. The former, with a greater angle to the horizon, reveals more of the top of an object; the latter, with a more acute angle, reveals more of the side of an object. The projectors are not reduced. Sopwith's world of parallel projection encompasses the isometric drawing and the 'verti' projections.[12] While these 'vertical' (oblique) drawings were lauded by Sopwith for their usefulness, their inclusion may have led to some of the latter confusion ascertaining what constitutes an orthographic projection.

At Cambridge, Robert Willis succeeded Farish as the Jacksonian professor of natural philosophy, holding the post from 1837 to 1875. He carried on Farish's tradition in more ways than one. Like Farish, Willis lectured on mechanical philosophy; furthermore, Willis 'adopted Farish's method of illustrating his lectures by means of models built up of component parts'.[13] In 1851, Willis published his *System of Apparatus for the Use of Lecturers and Experimenters in Mechanical Philosophy.* This was a documentation and communication of his practical teaching method in which his refined construction kit was used to demonstrate the mechanical principles of a variety of machines *[4]*. Three plates were appended to the book in which the components and apparatus are documented, almost exclusively in isometric perspective.

More significantly, Willis played with Farish's isometric perspective to illustrate architecture prior to refining it as the graphic component of his pedagogic kit-of-parts demonstrating mechanical science. While himself a student at Cambridge, Willis attended Farish's lectures and experimented with the drawing form before taking his professorship in 1837.[14] Prior to and concurrent with his professorial endeavours, Willis pursued a personal interest in architecture and archaeology.

In 1835 Willis published his first book on architecture, *Remarks on the Architecture of the Middle Ages, Especially of Italy.* His nephew, and later collaborator, wrote of this work:

> *'he treated a building as he treated a machine: he took it to pieces; he pointed out what was structural and what was decorative, what was imitated and what was original; and how the most complex forms of mediaeval intervention might be reduced to simple elements.'*[15]

Willis did not delve into the structural mechanics of the building's structure. More aptly, he applied his mechanical-analytical method to both the form and the process of investigation. This first work was illustrated with 15 plates, only one of which makes use of isometric perspectives *[5]*. The drawings on this one plate are analytic, as opposed to illustrative, and as such differentiated from other contemporary isometric representations. Figures 2 and 4 are iconic isometrics. Figure 1 however has three differently inclined axes to the plane of projection. What constituted an isometric is clearly in question; Farish's method of isometrical perspective was also quickly taken up by German engineers, geometers, and mathematicians.

German axonometry

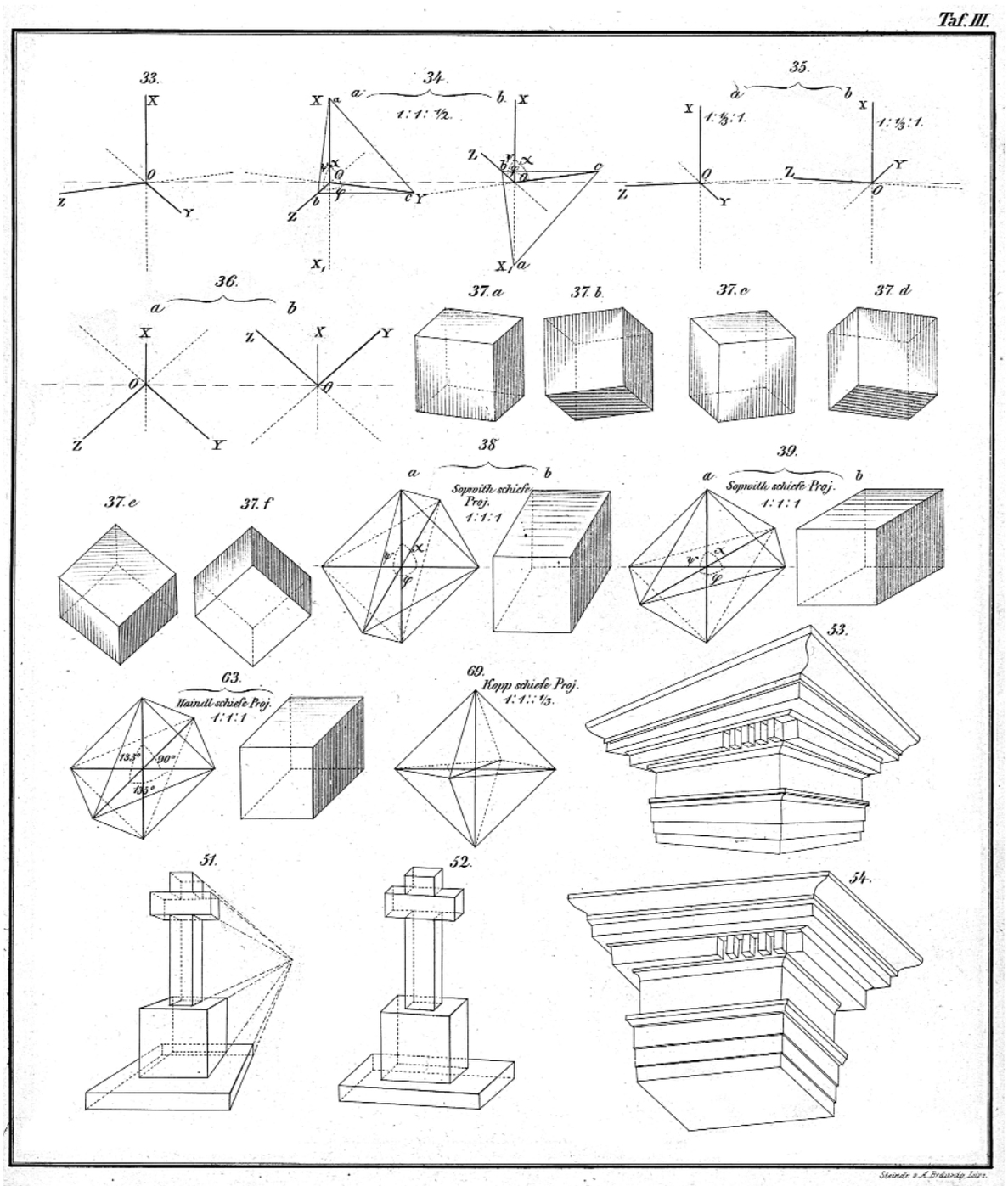
The critical geometric, trigonometric evolution of isometry toward axonometry is generally accorded to German Professor Julius Weisbach (1806–1871) and located in a brief scientific article, 'Die monodimetrische und anisometrische Projectionsmethode (Perspective)', published in 1844 in the *Polytechnische Mittheilungen*. Weisbach built on the nomenclature and theories of crystallography and the isometrical methods successive to Farish to establish a projective axis system. This is a critical change. The orthogonal projection was shifted from a cube to a spatial three-dimensional axis. Weisbach theorised that points could thus be projected by their coordinates on the axial planes.[16] As such, the orientation and reduction of the axes did not have to stay isometrically inclined and equally reduced. Yet, while Weisbach differently coordinated the space of the isometric, he did not use the term axonometric to encompass these newly defined axially rotated projections. This occurred eight years later in 1852 by the Meyer brothers.[17]

Meyer and Meyer proposed in their *Lehrbuch der axonometrischen Projectionslehre* that Weisbach's axis system, comprised of isometric, monodimetric, and anisometric projections, be named axonometry, and that the method be called axonometric projection *[6]*. Whereas Weisbach's work was exclusively theoretical, Meyer and Meyer comprehensively explored axonometric projection's theory and practice through its history, aesthetics, geometry, mathematics, process, and application.

The Meyers aimed to make abstract geometry practical.[18] They do not posit a single method by which to structure axonometric representations. They reason that one can find the axis-system both by calculation and by drawing.[19] The Meyers' axonometric methods are clearly in the realm of analytic geometry, as first conceived by Weisbach, and not in that of Monge's descriptive geometry.[20] They submit that such descriptive geometrical methods require excessive steps by generating the projected representation from two planes, and so first require geometrical drawings of both the plan and the elevation.[21] The Meyers construct their axonometric projections in space; the representation is bound to axiality. Their axonometric drawing methods are demonstrated by first determining the desired orientation of the axonometric axes, and by consequence the orientation of the rotated or revolved object in space.

The brothers' presentation argues that the axonometric method is not only a means by which to manifest an image of real bodies in a single picture, but also that the picture has the same effect as the object itself.[22] Meyer and Meyer contend that the axonometric is truly spatial. Points, lines, surfaces, and bodies as located in space are projected on one picture plane.[23] The values of true form and size are juxtaposed in space. Under axonometric projection, the figurative representation on the plane of projection allows one to understand the true spatial nature of bodies. Meyer and Meyer assess this spatial view of parallel projection in relation to that of conic

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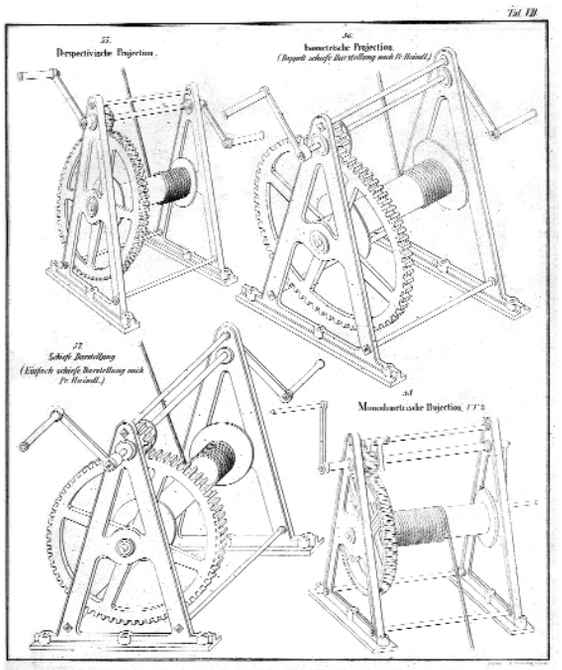
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perspective. The Meyers argue that central perspective, the 'painter's perspective', finitely restricts the image to the eye;[24] whereas axonometric projection, by virtue of its true parallelism in infinite space, 'allows the eye to hover at each single point' and is thus liberated and imaginative.[25] The invented views fabricated by axonometric projection are contingent on a different conception of the object and man *in space*.

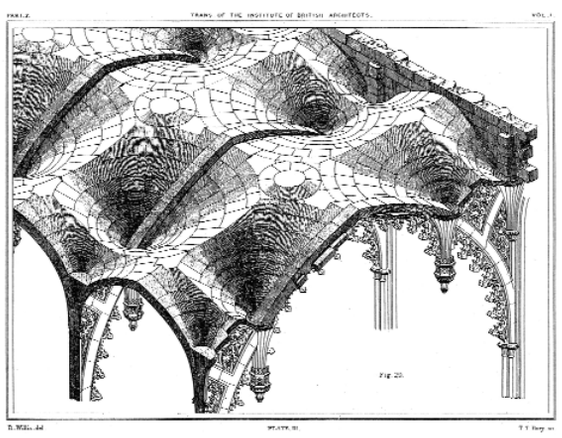
Furthermore, in a graphic comparison between a perspective projection, an isometric projection, a monodimetric (axonometric) projection, and an oblique representation, the authors argue that the difference between perspective and axonometric projections are negligible, as the rotation of the axis system allows one to very closely approximate a point of view similar to the conic perspective *[7]*. The inclinations of the perspective and monodimetric drawings to the picture planes are closely approximated in order to better make comparisons.[26] The Meyers argue that the monodimetric representation so closely approximates the perspective that the impression is the same. Indeed, they assert, distortion brought about by the convergence of the perspective's projectors introduces some doubt as to the reality of the real machine. Furthermore, the practical aspects of the monodimetric should be obvious.[27]

The brothers differentiate as well the axonometric views from oblique projection, or 'cavalier perspective'.[28] They comment, 'the picture developed by the oblique projection is like an orthographic shadow.'[29] The resultant images from the two systems are different and one sees different things. Meyer and

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6 Axial rotation in space results in axonometry and is characterised by isometric, monodimetric, and anisometric projections. Meyer and Meyer, *Lehrbuch der axonometrischen Projectionslehre* (Leipzig, 1855–1863), Plate III

7 Comparison of perspective, isometric, oblique, and monodimetric projections. Meyer and Meyer, Plate VII

8 Isometric representation of Westminster fan vault, R. Willis, 'On the Construction of Vaults in the Middle Ages', *Transactions of the Royal Institute of British Architects*, 1. 2 (1842), Plate II

Meyer concede that oblique projections are easier to construct than axonometric projections since the projection plane is parallel to, or coinciding with, one of the coordinate planes.[30] Within this plane, and parallel to it, there is simple geometric truth; circles are circles and right angles are right angles. Yet, while the axonometric method allows one to explicitly determine the foreshortening scale of any chosen inclination given to the oblique projectors from this orthogonal plane, the angle itself is nevertheless always arbitrarily or conventionally selected.[31] It is thus not relationally exact, as in the space of axonometry. They resolve that the inherent geometrical orthogonality of oblique representations relate more like the diagram, than the object itself.

Moreover, the Meyers' elaborate that establishing a *point of view* in axonometry does not conclude with the selection of an axis-system. Within the same axis system and ratio of reduction, there can be varied points of view. The inherent revolving spatiality of the parallel, axonometric axis system allows reversibility; they state, 'One can also exert an inverse bias with this axis-system, so that the observer may see into the system as at an angle or from below'.[32] Figures 33 through 36 (seen in *[6]*) highlight the potential for transpositions within the same axis system and the same ratio via the axonometric lines; first they are articulated forward, then backward.[33] It is within the context of a perspective and monodimetric comparison that we see the Meyers' only worm's-eye view representation, fig. 54.[34] The reverse axis, the same monodimetric relation as that conveyed in the demonstration cube, is used to convey a comparable image to the up view perspective of an Ionic entablature. The Meyers conclude that these rendered impressions are similar, but the tectonic view is more consequential than the exclusive eye view.[35]

The Meyers' serial publications on axonometry were followed in 1857 by a book by Julian Weisbach. As he was the first to posit the theory of axial rotation, it is not surprising that at that time he did not envision its extensive practical utility. Weisbach's *Anleitung zum axonometrischen Zeichnen* at first seems to be aimed at minimally modernising his first theoretical essay in light of the expansive theory and practice of axonometry as a method of representation advanced by the Meyers. Yet, within Weisbach's book there is a note of innovation; seven figural geometrical constructions demonstrate the projection of axonometric shadows. Mathematical historian Gino Lorio asserts that Weisbach's application of shadows firmly establishes the axonometric's place as a method of representation and not merely a mathematical or geometrical operation.[36]

In terms of architectural representation, this aesthetic position seems to have been anticipated by Robert Willis. In 1842, Willis continued his use of isometric renderings to portray different vault systems in 'On the Construction of Vaults in the Middle Ages'. These representations are less obviously analytic than his earlier work, but make manifest an atmospheric image of the mechanical relationship between stones, as component parts, and their assembly, as vaulted structures *[8]*. The stripped down, constructive essential skeleton is scientifically and spatially revealed, with parallel lines that belong to the world of the object, while shadows tie the object to an embodied eye.

The drawing out of axonometry in the mid-nineteenth century bifurcated the known world of parallel projection. An inherent difference between the axonometric and cavalier or oblique projections became apparent: the axonometric manifests a true spatial representation in and of three-dimensional space and the oblique offers a synthetic picture via shadow, diagram, and two-dimensional extrusion. The Meyers allowed that the axonometric projection

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is a spatially imaginative view and in doing so questioned the implicit bird's-eye view. The Germans fundamentally shifted the space of representation. Their axonometric method allows for observer specific orientations, reversible views, and analytic techniques. All of which can be variably used to impart a subjective point of view to the accurate spatial parallel representation of the tectonic object. The domain of parallel projection is paradigmatically changed from one ruled by the conventions of oblique projections in which the view is fixed through the system of projection to a realm which allows manipulation of the system in space to give rise to a desired 'point of view'.

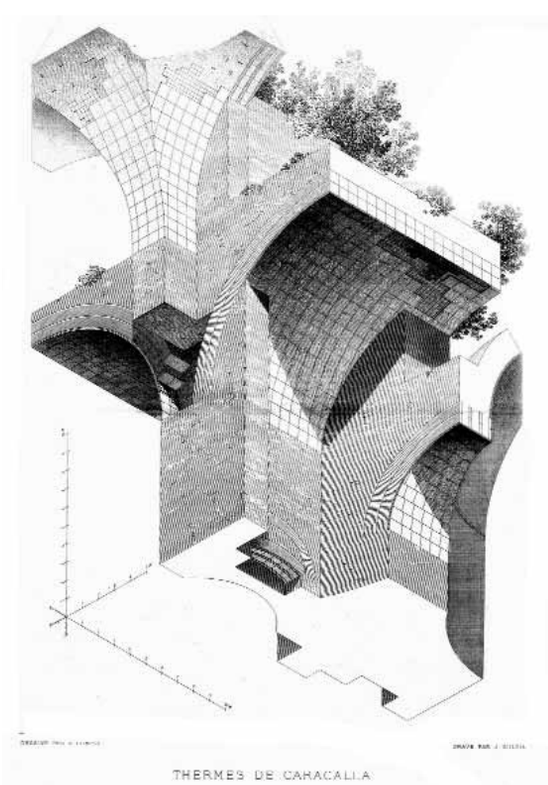
Auguste Choisy's axonometric and oblique projections

In light of the history of axonometry we ultimately see Auguste Choisy (1841–1909) as the first to put all these new theories into practice in the architectural realm. In his first published work, Choisy manipulates axonometry's varied but specific axial revolution, its inherent reversibility, and the aesthetic use of shadows. Each reconstruction in Choisy's 1873 tome, *L'art de bâtir chez les Romains,* exhibits a varied, specific rotation and position of the object in space. Through the rotationality of axonometry, Choisy launches both the oblique projection and axonometric projection into space, with the worm's-eye view *[9, 10]*. Spatial dynamism of tectonic space is captured in these up-views. Choisy's sketches and drawings demonstrate the relationship between his constructive logic and the worm's-eye view. The observer inhabits the space under the vaults of the Roman engineers; the structure builds from the earth to the sky to delimit architectural space. The up-view is phenomenally paramount.

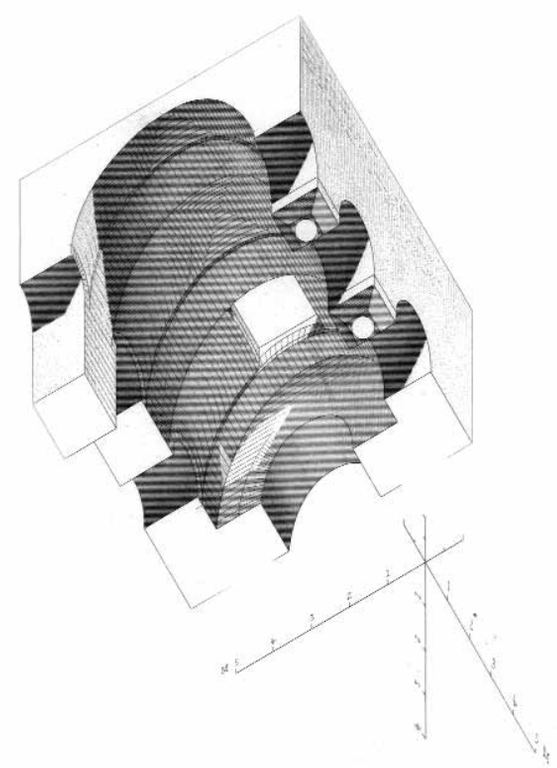
While the axial revolution of axonometry allowed for the conception of his reverse up-view, Choisy applies the rotation to oblique projection as equally as to axonometric projection in his early works. Both types of parallel projection are used to construe building in a poetic way by introducing a human sense of dwelling within a rational technical abstract representation. The viewer is pulled inside and imaginatively inhabits a tectonically constructed space. Man does not exist in the world of parallel projection, yet Choisy entices us into the space of the vault. Unlike a static perspective, the viewer is pulled into the space of the structure and allowed unfettered freedom to roam within. This simultaneity seems intended by Choisy, as he later reflected: 'In this system, one sole image is lively and animated like the building itself'.[37] The drawings engage the poles of the real and the fictitious, the rational and irrational. Choisy stimulates spatio-tectonic imagination. The drawings create a carefully crafted imaginative world of architecture from the architectural ruin. Choisy's parallel projections introduce a modern form of representation, straddling the world of the object and subject which was only imaginable through the axial rotation of axonometric representation.

While axonometric and oblique projections are used diversely in *L'art de bâtir chez les Romains* (1873) and its successor, *L'art de bâtir chez les Byzantins* (1883), one can discern Choisy's use of the inherent spatial differences in his *Histoire de l'architecture*, published in 1899.

Within the *Histoire*, Choisy intimately ties the plan to the space of structure with his oblique and axonometric projections. With oblique projection there is simultaneity between the geometric purity of the plan, its proportions, and geometry as juxtaposed with the spatial organisation of the

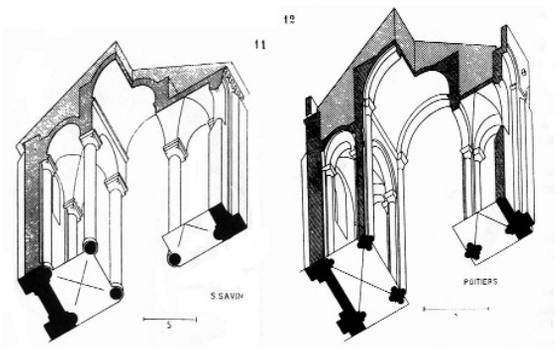


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9 Isometric axonometric projection, A. Choisy, *L'art de bâtir chez les Romains* (Paris, 1873), Plate V

10 Oblique military projection, A. Choisy, *L'art de bâtir chez les Byzantins* (Paris, 1883), Plate VII, fig. 1

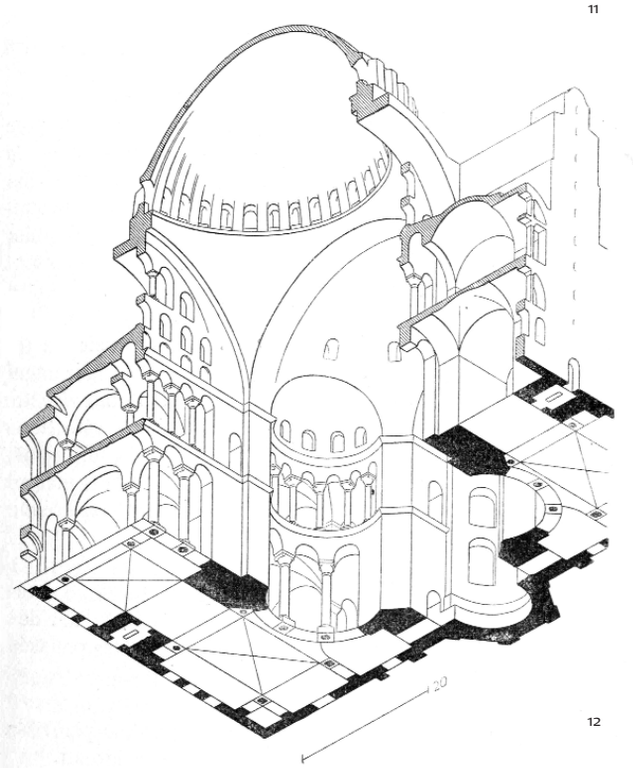
11 Worm's-eye view, plan based, oblique projections convey the spatio-tectonic progression of Romanesque architecture. The comparative sequence exploits the inherent planar property of oblique projection. A. Choisy, *Histoire de l'architecture* (Paris, 1899), II, pp. 203–9, figs. 11, 12, 13, 16; St. Savin, Poitiers, Parthenay, Issoire

12 Solitary expression of *Sainte-Sophie de Constantinople* using axonometric projection. A. Choisy, *Histoire de l'architecture*, II, p. 49, fig. 13

structure *[11]*. Not only does the up-view animate the structure above our heads, but the worm's-eye view grounds the architecture to its organising plan. The ground plan contains many of the key aspects of a project, at once a means of representation, an architect's design tool, and a layout and instruction pattern for the builder. Though the ground plan is invisible to the inhabitant, it determines with precision the quality of the spaces we inhabit. Choisy exploits the inherent planar property of oblique projection to ground his comparative sequences of the spatio-tectonic progression of architecture to the pure geometry of its organising plan. Graphic abstraction via oblique projection is an essential quality used to shift his graphic representations from illustration to theoretic expression.

As opposed to the oblique projections, Choisy's axonometric drawings exhibit dynamic singularity *[12]*. Axonometric projection is not used extensively in the *Histoire*. Isometric and dimetric axonometric projections communicate the effect of architectural form *in* space and *as* spatial. The axonometric embodies architecture's movement, spatiality, animation, harmony, variety, character, and sculptural qualities. The oblique attributes of the orthographic projection encourage an impressionistic reading or view. The discretely used axonometrics exhibit the harmonic activation of the whole of the parts in space. Space now becomes one of the essential elements of architecture – joining the column, the arch, the vault. The distortion of the plan agitates the structure, amplifying the space.

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Axonometric space

An abridged survey of iconic 'axonometric' representations of the twentieth century, from van Doesburg to Sartoris, Koolhaas to Tschumi, and including Eisenman, Holl and Stirling, demonstrates that most drawings are not axonometric, but rather oblique projections.[38] In these representations, it is possible to immediately discern the benefit achieved through maintaining the two-dimensional geometric purity stemming from the fact that one plane of the object lies parallel to the picture plane in such projections. I suggest that most representations broadly identified as axonometric are in fact oblique projections, particularly based on the historic facts of the system of parallel projection. Clearly, there are phenomenal spatial qualities that differentiate the two forms of projection which offer different potentialities. While oblique projections following Choisy's abstract graphic language can be seen throughout the twentieth century, the promise of the axonometric has not been pursued.

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Notes

1. Massimo Scolari, 'Elements for a History of Axonometry', *Architectural Design*, 55.5–6 (1985), 73–78 (p. 73).
2. Jean Baptiste de la Rue and the Académie royale d'architecture (France), *Traité de la coupe des pierres: ou, Méthode facile et abrégée pour se perfectionner en cette science* (Paris: Libraire du Roi, 1764), title page. 'Méthode facile et abrégée pour se perfectionner en cette science'. First published in 1728 by Librairie des arts et métiers.
3. Jules de la Gournerie, 'Mémoire sur l'enseignement des arts graphiques', *Journal des Mathématiques,* 2nd ser., 19 (March 1874), 113–156 (pp. 146–7). 'Monge et ses disciples n'ont rien écrit sur la Perspective cavalière, mais, en fait, ils la repoussaient [...]. Le rejet de la Perspective cavalière me semble être une conséquence naturelle de la doctrine de Monge.'
4. William Farish, 'On Isometrical Perspective', *Transactions of the Cambridge Philosophical Society,* 1 (1822), 1–19 (p. 4).
5. Ibid., pp. 5–6.
6. Joseph Jopling, *The Practice of Isometrical Perspective* (London: M. Taylor, 1842), p. 14.
7. Ibid., p. 18.
8. Ibid., pp. 19–20.
9. Thomas Sopwith, *Treatise on Isometrical Drawing* (London: John Weale, 1838), p. 222. First published in 1834.
10. Ibid., appended page 4 of 'works published by the author'.
11. Ibid., p. 141.
12. Ibid., plate 17.
13. Thomas John Norman Hilken, *Engineering at Cambridge University: 1783–1965* (London: Cambridge University Press, 1967), p. 51.
14. Ibid., p. 51.
15. *Dictionary of National Biography from the earliest times to 1900*, ed. by George Smith and others (London: Oxford University Press, H. Milford, 1938), XXI, p. 493. The entry was penned by Willis's nephew, John Willis Clark.
16. Martin Herrmann Meyer and C. Th. Meyer, *Lehrbuch der axonometrischen Projectionslehre* (Leipzig: H. Haessel, 1855–1863), p. 13, 1n.
17. Meyer and Meyer's work was published serially as *Lehrbuch der Axonometrie* between 1852 and 1855, and finally published together in 1863.
18. Meyer and Meyer, p. 12.
19. Ibid., p. 87.
20. Gino Loria, *Storia della geometria descrittiva dalle origini sino ai giorni nostri* (Milano: Ulrico Hoepli, 1921), p. 414. Loria merely cites the work of Meyer and Meyer. He offers no discourse. It is not clear that he saw their work. He credits Weisbach with developments which were preceded by Meyer and Meyer.
21. Meyer and Meyer, p. ix.
22. Ibid., p. v.
23. Ibid., p. 1. 'Die räumlichen Grössen (Linien, Flächen und Körper).'
24. Ibid., p. 1. 'Malerperspective.'
25. Ibid., p. 1. 'Bei welcher das Auge über jedem einzelnen Punkte stehend.'
26. Ibid., p. 58.
27. Ibid., p. 57.
28. Ibid., pp. 8–9.
29. Ibid., p. 2. 'Das durch dieselbe entstehende Bild ist gleichsam der orthographische Schatten.' This contention is repeated throughout the volume.
30. Ibid., pp. 59–60.
31. Ibid., p. 60.
32. Ibid., p. 50. 'Dass man auch bei diesen Axensystemen eine Neigung nach hinten vornehmen kann, so dass der Beschauer gleichsam schräg von unten in das System sieht, bedarf seiner weiteren Erwähnung.'
33. Ibid., p. 50. Plate 3, fig. 36.
34. Ibid., p. 50. Plate 3, fig. 54.
35. Ibid., pp. 57–8.
36. Loria, p. 419.
37. Auguste Choisy, *Histoire de l'architecture*, 2 vols (Paris: Gauthier-Villars, 1899), Note. 'Dans ce système, une seule image mouvementée et animée comme l'édifice lui-même [...].' The 'Note sur le mode de présentation des documents graphiques' first appeared in the 1905 edition.
38. Reference the following twentieth-century oblique projections commonly identified as iconic axonometric representations: 1923, Theo van Doesburg and Cornelius van Eesteren, Contra-Construction; 1931, Alberto Sartoris, Notre Dame du Phare; 1972, Rem Koolhaas and Madelon Vriesendorp, City of the Captive Globe; 1975, Peter Eisenman, House IV transformation Study; 1984, Steven Holl, Berkowitz House; 1989, James Stirling, Electra Bookstore.

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Biography

Hilary Bryon recently received a Ph.D. from the University of Pennsylvania and is currently an Assistant Professor in the School of Architecture + Design at Virginia Tech. Her ongoing research into graphic representation was first piqued by the imaginative constructs of Auguste Choisy.

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