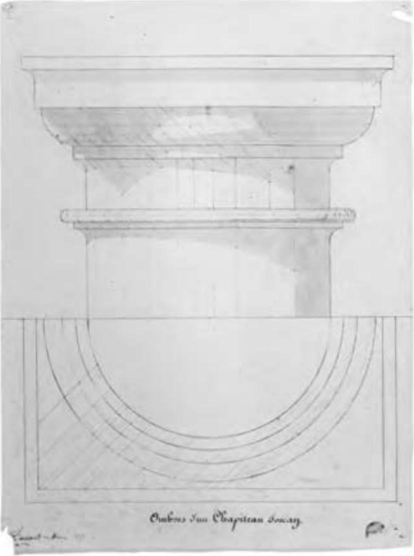


Fig. 1. F. Bertrand the Elder, *Shadow Cast by a Tuscan Capital* (1817). Pen and black and red inks with grey wash on laid paper. 38.6 x 43.8 cm. CCA [illegible]

Architectural Projection

ROBIN EVANS

ARCHITECTURAL DRAWINGS are projections, which means that organized arrays of imaginary straight lines pass through the drawing to corresponding parts of the thing represented by the drawing. We are all very familiar with projected images. The pictures on a television screen are projections. Converging lines of light reflected from a subject are gathered by a camera lens and focused on a photo-sensitive surface. This is a projection. The resulting image is turned into electrical signals that are transmitted to a cathode-ray tube where they are remustered in a scanning electron beam, the pattern of which sketches a duplicate of the original cone of light rays in reverse. When they hit the fluorescent screen they create another image. This is also a projection, as are photographs and motion pictures. We are surrounded by these flat versions of embodied events to such an extent that they have long since ceased, in themselves, to be a matter of any amazement, or even of mild curiosity. We are prone to think of them as part of the ever-expanding technology of information transfer. Projection has been incorporated into so many electronic and mechanical processes that it no longer needs much space in our imagination. We do not normally have to think spatial relations out this way, and there seems little point in making anyone do so when it can be done instantaneously with such exactitude and facility in a black box.

With the profusion of reproduction techniques, things become flatter. At any rate the vast majority of projections work that way, since two-dimensional information is so much easier to handle than three-dimensional things. In practice, projection has become thoroughly directional because of the availability of certain instruments and machines for making pictures; but there is nothing in projection itself to suggest directionality. It can work either way round. Architecture provides an instance of the opposite tendency, taking information from flat representations to create embodied objects.

There are, of course, plenty of drawings in architectural archives that illustrate existing buildings. Like television or photography, they record things already made; they do not project things as yet unmade. Still, it is not always easy to tell the difference between the two categories. When a scheme has been finished and drawn up ready for production, it is frequently shown in as flattering and, at the same time, as realistic a light as possible, in what are called presentation drawings (see cat. no. 30.2). Presentation drawings are not supposed to have any effect on the design. Their job is to propogate a completely defined idea, not to test it or modify it. They should then be classed as records. And yet what they record is not real. To use the word projection in a completely different sense, they are projections of a plausible outcome for a set of instructions and proposals already defined elsewhere but not yet accomplished. Their status is unclear because they are neither impressions received from a real object, as would be a perspective from life or a photograph, nor are they directly instrumental in the making of what they represent. They are neither received from nor transmitted to a building, but are pulled into a sort of *cul-de-sac* somewhere between the beginning and the end of a process.

It may seem odd to contrast the two ways projection transmits its information only to embark on the description of an ambiguous case. It may well give the impression that the distinction is uncertain and of little practical value. My intention, however, is to point out a very common property of architectural drawing in general. Projections–the invisible lines that relate pictures to things–are always directional. Drawings arrest and freeze these vectors, but even in this fixed state, projected information can be mobilized by the imagination of the observer. When a workman looks at a workshop drawing and envisages what the finished result of his labour will be, he is, by

envisaging it, briefly turning the projection around, cutting out the final term by predicting the result of its existence before it has been made. The arrow does not go straight from A to B. As soon as we introduce the observer with a capacity to imagine–and indeed who must, in order to accomplish his task, have a clear idea of what he is doing, a clear mental picture of what he is aiming to produce–then the line between the design drawing and the finished article seems to be composed of a series of eddies and circuits rather than a single vector. There is always a touch of illustration in even the most abstruse and diagrammatic visual instruction, and illustration always prompts us to envisage what it portrays as if it were already real, even when we know it is not. This suggests that some aspects of the imagination are sufficiently similar to projection to be compared with it, or even confused with it.

Similar diversions and reversals occur at a different tempo in the making of topographical records, where it is normally assumed that the subject will be *unaffected by its portrayal*. Draw a building and it will be the same building when you have finished drawing it, neither more nor less. Visual knowledge alights on its subject without taxing it, without expropriating anything from it. Obtaining it can be, and often is, a very gentle, considerate, subtle affair, although there are stories to suggest otherwise, like the one told by Max Ernst about his father. Ernst the elder, a scrupulous realist, was painting a view of his own garden, and finding it unsatisfactory unless a certain tree was omitted, first subtracted the tree from the composition and then afterward removed the tree from the garden.[1] This sounds ludicrous because we are prone to think it more likely that Ernst the elder was a bad painter than that the tree in the garden was at fault. Yet is there not, in fact, a constant interplay between the passive portrayal and the active remodelling of reality? Might this help explain why the accurate representation of objects, all assimilation and no effect, became so important to western civilization during a period when it was extremely aggressive and rampant, from the fifteenth to the nineteenth century?

It is admittedly unlikely that someone would draw the Parthenon and then decide to haul off the odd offending piece–not just rub it out but remove it from site, the way Ernst the elder removed the tree. No such vandalism would now be tolerated to so prestigious an item. Drawings of it have nevertheless done something like this by stealth, helping to convey a large variety of civic likenesses from Edinburgh to Buenos Aires. It is one thing to establish a canon of great works of architecture; it is another to be able to copy and duplicate it in whole or in part. The Parthenon cannot be demolished by drawing, but it can be burgled; its forms stolen and reconstituted by virtue of this same, not so passive agency of projection.

The observer's imagination, itself comparable to projection, complicates the simple two-way traffic between things and their pictures, causing unpredictable diversions and re-routings. If we subtract this destabilizing element, then we would have to judge only by results, which is much easier. The drawings produced by William Butterfield's office for St Matthias in North London (cat. nos. 39.1–39.2), Nesfield's shop drawings for furniture (cat. no. 40), and Ernest Cormier's drawings for the Palace of Justice in Montreal (cat. nos. 41.1–41.5) then lead ineluctably to their final destinations: house, church, and courthouse–just as ineluctable a journey as that from a completed building to its photographic image. It is sometimes convenient to do this, but the subtraction should be performed as a temporary measure. If the activating imagination is permanently removed from consideration, drawing very easily slips into the category of a mere technical facilitator, and this results in two illusions: first, that it makes no difference to what is drawn (unless done incorrectly); second, that drawing can propagate things, but never generate them. These illusions will persist as long as we regard good drawing as a simple truth-conveyor. As much can happen in the drawing as out of it.

According to ancient wisdom, architects make images from ideas. Theologians were fond of quoting St Thomas Aquinas on this theme. An architect, wrote Aquinas, first has an idea of a house and then he builds it. God made the World in similar fashion. Aquinas's architect still haunts us; he thinks, therefore he draws. He draws the bodyless but fully-formed ideas from the mind and puts them on paper, just as Ernst the elder put trees on canvas. But Aquinas's architect is a figment. There may be such creatures, but they would not be possessed of much in the way of creativity; quite the contrary. Imagining with the eyes closed, as if the whole world were held in the mind, is an impossible solipsism. The imagination works with eyes open. It alters and is altered by what is seen. The problem is that if we admit this, then the relation between ideas and things turns mutable and inconstant. Such destabilization is bound to affect our understanding of architectural drawing, which occupies the most uncertain, negotiable position of all, along the main thoroughfare between ideas and things. For this same reason, drawing may be proposed as the principal locus of conjecture in architecture.

Most of our knowledge of great architecture comes from pictures. One could therefore imagine a situation in which embodied architecture–not the everyday buildings that we are used to, but buildings in the "great works" category–was hardly more than a rumour of an intervening state. We could, if we wished, treat great buildings that way, since they are anyway so completely surrounded by their own projected images. They are set in an aura of illustration that no doubt alters the way we see them. As critics become more aware of the active role played by photography in the propagation and maintenance of architectural ideas, this intervention becomes clearer.[2] There is also a growing awareness of the active role of drawing in the engendering of certain architectural forms and in the maintenance of others. As an instance I would cite Robert Branner's speculation that the attenuated, linear, panel-like character of *rayonnant* Gothic architecture is attributable to the introduction of scaled project drawings on parchment sometime before 1240. He thinks Cambrai Cathedral was the first building conceived this way.[3] We are now witnessing a critical pincer movement that is at once more aware of, more wary of, and more interested in the

active part played by the images on either side of architecture.

The modish thing to do would be to argue that, in this expanding field of projections and images, the building itself has no special priority; that it is only habit that makes us insist with some indignation that it should maintain the priority it once had, that it has always had, or that we think it ought to have. Slightly less modish, but very self-righteous, is the stand taken against *any* drawings or pictures because they get in the way of our direct and authentic perception of architecture. The first argument is easily tenable, but very disturbing in its implications. The second is tenable only if one discounts the entire history of western architecture, which has always been dependent on pictures for purposes of construction and dissemination. It is easy to hold opinions of whatever stamp in the absence of a full understanding of their consequences. At present we are only just beginning to investigate the power that drawings and photographs have to alter, stabilize, obscure, reveal, configure, or disfigure what they represent. Whatever the final outcome of these investigations, we can be certain of one thing in the meantime: architecture is reliant on its own pictures to a far greater extent than has hitherto been recognized.

In what follows I shall try to give a brief summary of one side of this reliance: the pictures that precede the act of building.

The images with which we are most familiar are perspectival. In perspective projection, the array of imaginary lines mentioned at the outset of this essay all converge on a single point. They behave in exactly the same way as light rays converging on the eye do. Thus, although these imaginary lines, called *projectors*, have no real existence, they mimic the pattern of something that does exist, and that is why they can be relied upon to produce pictures that look like or, under restricted conditions, are precisely congruent with, what they represent. They ape the geometry of monocular vision.

However, the kind of drawings used in the professional design, production, and even illustration of architecture are not perspectival. They are what is called orthographic projections (or architectural projections, engineering drawings, geometrical drawings, parallel projections, cylindrical projections, or descriptive drawings). In orthographic projection the projectors do not all converge to a point, but remain parallel. Because this is not the way we see things, orthographic drawing seems less easy to place. It does not correspond to any aspect of our perception of the real world. It is a more abstract and more axiomatic system. This is why so many people find such drawings difficult to read at first sight. The advantage of orthographic projection is that it preserves more of the shape and size of what is drawn than perspective does. It is easier to make things from than to see things with.

So it is not surprising that orthographic projections are more commonly encountered *on the way to* buildings, while perspectives are more commonly encountered *coming from* buildings. This gross truth has not prevented a high degree of mixing and slippage between the two, not least because those expert in the one have tended to be expert in the other. Such slippage cannot be allowed to obscure the fact that, in architecture, orthographic projection has been the preponderant method for devising, picturing, and transmitting ideas of buildings before they are built. So this essay will be principally concerned with orthographic projection.

The question remains as to how it works. Orthographic projection is not in the slightest degree mysterious, and yet its employment in architecture raises many imponderable questions, the most pressing of which have to do with the enigma of how architectural ideas are given definition prior to being constructed. If we think in terms of art, this anterior definition of the object, whereby all significant decisions are normally taken before the thing itself is even begun, is peculiar to architecture. It would be foolish, it seems to me, to characterize architecture as abstract, since a house is no more abstract than a chair or a biscuit; but it makes a great deal of sense to call the process of its conception *abstracted*. Architects do not make buildings; they make drawings of buildings. Other things are similarly conceived–engineering and legislation, for instance–but they are not usually thought of as art.

It is possible to see how projection works on the things it projects only by close scrutiny and inspection of examples. I have chosen therefore to take a number of specific drawings from the CCA collection to show the different ways projective drawings have been employed, how they are constructed, and, above all, how they are implicated in shaping the buildings they represent. Some indication of historical developments has been given, but it is incidental. The choice has been made with a view to distinguishing the different ways drawings work on the conception of buildings, rather than giving a chronology of techniques or differentiating the types of projection used.

The imagination looms large here, but it is imagination construed, I have to admit, in an odd way: an imagination not located solely in the mind of the architect. Reference has already been made to the active imagination of the observer of the drawing; there is also an active imagination *in* the drawing itself. This has nothing to do with the mental faculty of imagining. Obviously, drawings do not think. But, because a drawing technique like orthographic projection was itself the product of intense imagination, this massive effort of imaginative intelligence lies dormant in it, animated to lesser or greater effect and to various ends every time the technique is used.

In some cases, necessarily rare, the imaginative intelligence of the architect is divided between inventing the drawing and inventing the thing drawn. Neither can have been taken for granted at the time, and in such circumstances the relation between projection and the projected is of considerable interest.

The first example is just such a case. It is a plate from the *Etliche underricht zu befestigung*, by Albrecht Dürer, published in Nuremburg in 1527 (fig. 2), showing the plan, section, and elevation of a fortification, and may be the earliest printed example of these three kinds of architectural drawing shown together, a matter deemed significant because we have come to re-

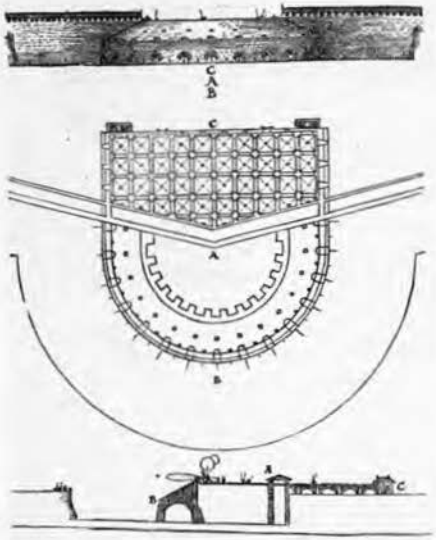


Fig. 2. Albrecht Dürer, *Design for a Bastion at the Angle of a Town-Wall*, from *Etliche underricht zu befestigung der Stett Schloss vnd flecken* (1527). Woodcut, page 29.3 x 18.9 cm. CCA 8216 Cage (cat. no. 1)

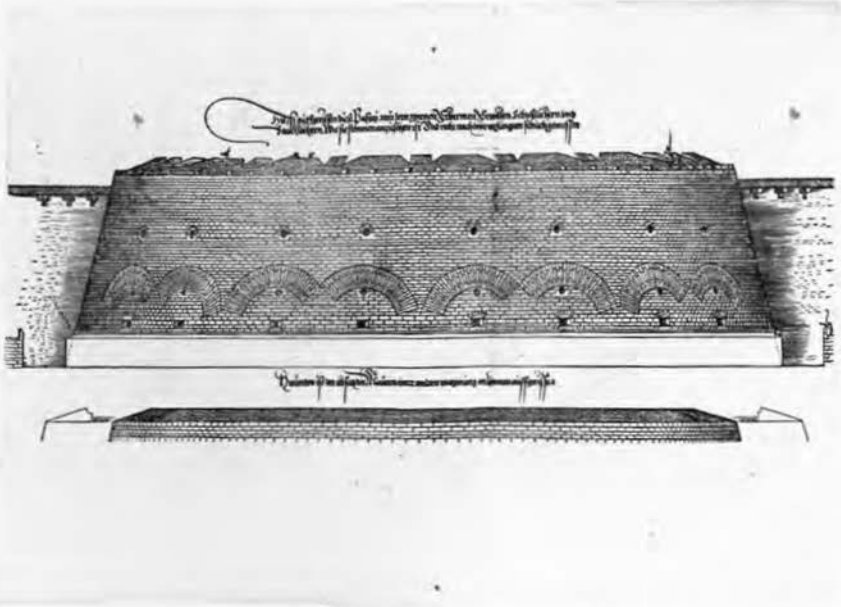


Fig. 3. Dürer, *Elevation of a Bastion*, from *Etliche underricht* . . . (1527). Woodcut, page 29.1 x 41.6 cm. CCA 8216 Cage

gard this set of three as fundamental. They are typical of architectural production, and had been established as such by the middle of the sixteenth century. However, the following plate in Dürer's book (fig. 3) shows something that is at least as significant; it is an enlargement of the elevation of the curved wall of the fortress, which, in the woodcut for the smaller drawing on the preceding plate, shows little in the way of detail. There are no projectors indicated on either drawing, but it is perfectly clear that the positions of the inclined and battered arches following the curvature of the wall were determined by projection. Anyone familiar with the established conventions of architectural drawing will have no difficulty recognizing that this was done by projecting parallel lines up from the plan until they met the outline of the elevation. The simplest procedure would be to divide the circumference in a number of equal parts to locate the arches on the plan and then push this information up; but a moment's further reflection will show that a far more complex operation is required in this case, because the surfaces from which the projectors are transmitted, and onto which they are received, are not box-like and orthogonal. The surface of the fortress wall is a thin slice of a cone, curving and inclined at the same time. Draw a simple arch on a sheet of paper with a compass. You can either wrap this around the surface of the cone, like a transfer, to get a bowed arch, or you can hold it flat and upright and project its shape onto the conic surface. In either case the resulting curves mapped in plan and elevation cannot be drawn with a compass.

What we see in Dürer's fort wall are shapes that are defined by projection. And it is important to notice that it is not just the shapes drawn, but the shapes that would have been built from the drawings that are defined this way. When we envisage wrapping the drawing of an arch around the conic surface of the fortress wall (not a projective operation), we have to do so before the wall is built. In order to know the shape of the arch we need the shape of the wall of which it will be a fundamental part: we cannot find the shape of the arch until we have the wall, and we cannot have the

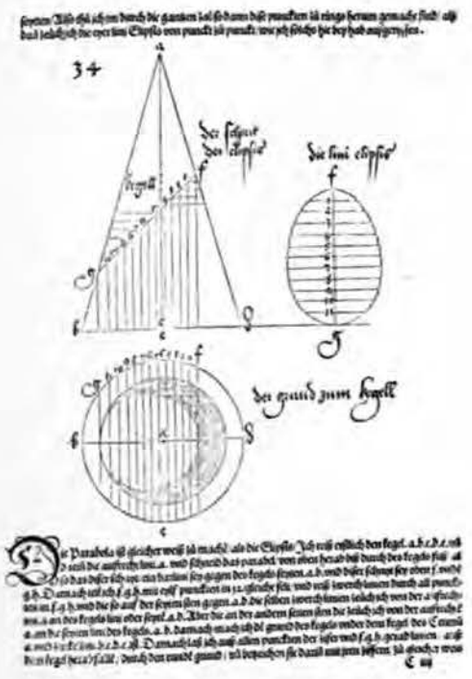


Fig. 4. Dürer, *Geometric Drawings of a Cone, Sectioned to Produce an Ellipse*, from *Underweisung der Messung* (facsimile reprint of the Nuremberg edition of 1525). Offset lithograph, page 29.8 x 20.0 cm. CCA 1085–B20156–1

wall until we find the shape of the arch. The virtual surfaces constructed through orthographic projection make it possible to open this vicious circle: the measurements of all parts can be known before a thing is made or modelled in three dimensions. Would Dürer's drawing have made any difference to the shape of the building proposed, or did it just emulate the shapes that would anyway have resulted from common building practice? The answer depends on the kind of construction: if it were mass construction on formwork, it could have been made without the drawing; if it were cut stone, then it could not.

Dürer, best known as a painter, was for several centuries also regarded as one of Europe's great geometers. If judgement on this point has mellowed somewhat,[4] he must still be accorded a key place in the development of projective drawing. He was an accomplished practitioner and exponent of perspective as well as orthographic projection. In the *Underweysung der Messung* (1525), his book on the construction of geometric figures, he illustrates a method for doing what he must have done in the fortress drawings: plotting information from a circular plan to a conic elevation by orthographic projection. He slices the cone with closely-spaced horizontal cuts, each of which is represented in plan by a circle of corresponding diameter (fig. 4). The line GF, an oblique cut through the cone, can then be thought of as a series of intersections with the closely-spaced slices. All one has to do is drop these intersection points onto the corresponding circles in the plan below. Dürer then added a third drawing that turned the resulting curve into the same plane as the paper on which it is drawn, taking the horizontal dimensions from the plan, and the vertical dimensions from the oblique line GF on the elevation. This is an ellipse. The particular technique of slicing a solid with numerous parallel cuts to facilitate the projection of information from one aspect to another was Dürer's invention.[5] It will not have escaped the reader that Dürer used the same set of drawings to represent the cone as he did to represent the fort: plan, section, and elevation. The only difference is that the section of the cone is at an oblique angle, not orthogonal. Since the conic drawings were published two years earlier, it is reasonable to assume that the set of plan, section, and elevation was used to describe the abstract geometrical figure *before* it was used to describe the concrete forms of architecture.

Behind Dürer's apparently crude set of woodcuts for the fort there is already a sophisticated understanding of projective relations. Several decades earlier, perhaps as early as the early 1470s, Piero della

Fig. 5. Dürer, *Mechanical Method for Making a Perspective Picture of a Lute*, from *Underweisung der Messung* (facsimile reprint of the Nuremberg edition of 1525). Offset lithograph, page 29.8 x 20.0 cm. CCA 1085–B20156–1

Francesca had been exploring the same things in the same way. He left the first explanatory account of orthographic projection in a brilliant and lucid work with many impressive drawings. Curiously enough, his treatment of parallel projection, though excellent, was incidental. The treatise, *De Prospectiva Pingendi*, was about perspective.[6]

Dürer must have known of Piero's treatise, either from studying it himself or through the mathematician who taught him perspective while he was in Bologna.[7] Both artists were investigating a technique of perspective construction much easier to use with

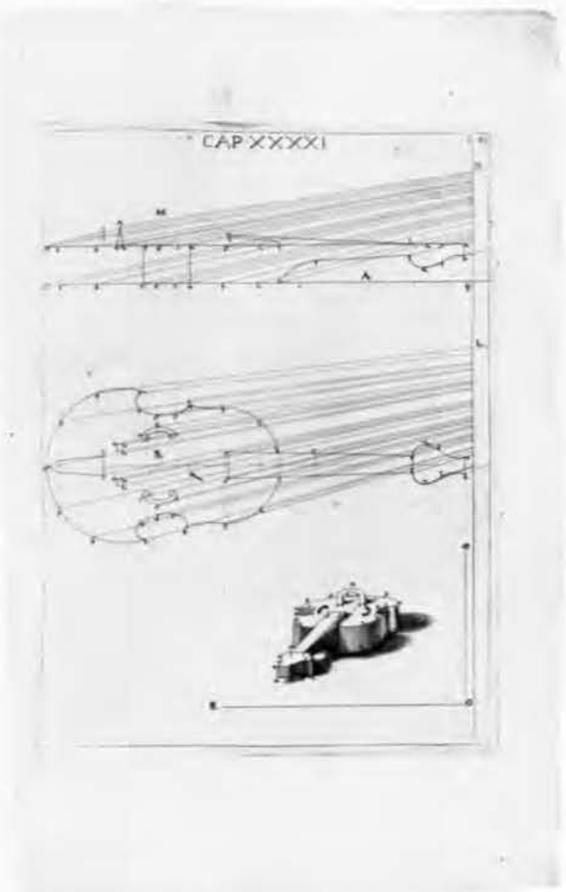


Fig. 6. Lorenzo Sirigatti, *Perspective Projection of a Lute from its Plan and Elevation*, from chapter XXXXI of *La pratica di Prospettiva* (1596). Engraving, plate 30.0 x 22.0 cm. CCA WM6200 Cage

real objects. In fact, Dürer's famous woodcut showing how to make a perspective image from an existing object–a lute–with the aid of a weighted line, two frames hinged together, and a cursor, indicates the straightforward optical realism from which issued the first accounts of orthographic projection (fig. 5). Piero demonstrated that a similar map of sight lines could be made from drawings alone if the lute was replaced by its plan and elevation. Similar demonstrations illustrating similarly curvaceous instruments can be found in many later works on perspective (fig. 6). It might seem, then, that orthographic projection was a laborious extra operation introduced only so that perspective could be demonstrated theoretically on paper, when it could be practised perfectly well without it. If painting had been restricted to the recording of optical impressions that would certainly be true: but it was not. What Piero and Dürer had made possible by the introduction of adjunct orthographic constructions (in all likelihood following Brunelleschi, the architect who first formulated the theory of perspective around 1420[8]), was the most exact description of imaginary things. Committing to paper the mapping procedure for real things enabled the invention of others. It was orthographic projection that brought the imaginary into the scope of perspective without relinquishing anything of its precision. That is surely a matter of considerable importance in painting, but, since the subject of this essay is architectural drawing, attention will be restricted to the architectural implications of orthographic projection.

The first thing to be noticed is the subordination of orthographic projection to perspective. With Piero this subordination might be attributed to his concentration on the latter. Yet the same bias can be discerned not only in architectural writers such as Alberti, Serlio, and Vignola, but also in the general level of coverage and the characteristic treatment of orthographic projection as a preparation for perspective, and if not perspective, then as a preparation for something else, like making classical buildings, making sundials, making ships, or cutting stone.[9] While hundreds of treatises were published on perspective, there were none dealing exclusively with orthographic projection until the very end of the eighteenth century.[10] Even now the *Encyclopedia Britannica* has ninety-six lines on perspective and only nine on orthographic projection. In consequence, while perspective may still be lauded as the great opener of western eyes, orthographic projection is relegated to the status of a technical matter: technical drawing; limited vision. Its usefulness in the pursuit of other tasks is what seems to have impeded its promotion as a form of knowledge.

The attention now being devoted to orthographic projection by critics and historians of architecture may, perhaps, change this, although sometimes even they bring this same ingrained prejudice to bear on the material they deal with.

The other ingrained prejudice that comes hand in hand with the above is that orthographic projection is either unconnected with imagination, or a positive hindrance to it. It must be clear from what has already been said that this has not always been so. It is an active agency in the formation of images, and it is a very effective agency for the elaboration of imaginary objects. That does not mean that it is good. It may well account for why it has sometimes been bad. Let us consider Dürer's woodcut. The imagination radiates through the medium of projection, giving shape to fortifications. As Massimo Scolari points out, there is something a little sinister in the close association between the development of certain kinds of parallel projection and military subject-matter, an association that was maintained till well into the nineteenth century, when the military applications were overtaken by industrial ones.[11] To my mind, these uses do not in themselves signify exhaustion, or even corruption, of the imaginative faculty. Imagination can be unprepossessing, but more usually its effects on the world at large are just ambiguous and dependent on circumstances. Dürer himself thought so, quoting an old adage to make his point: "A sword is a sword, which may be used either for murder or justice."[12] It is, he says, only misuse that makes things bad; all well-made things, in themselves, are good. The functional fortress may be justified this way no less easily, perhaps rather more easily, than some of Dürer's politically partisan representational projects, like the triumphal arch for Emperor Maximilian I, or his monument to commemorate the suppression of the Peasants' Revolt.[13]

The three drawings, plan, section, and elevation, are also partisan. Although theirs is a different type of partisanship, it too comes of partiality. We cannot see from Dürer's plate what material the fort is made of. We infer from the forms drawn that it is masonry; but

this is detective work, not specification. Like the moon, the fort shows us only one face, and all we know of its interior constitution is gleaned from the single cut of the section. Projective drawings of buildings are never exhaustive. They rarely impart much other than formal information, and even this is normally incomplete. We would assume that the partial description supplied by the conventional set is appropriate because it is the most significant information, and that the drawings are therefore well adapted to their task. But then it is no less likely that, over the centuries, the task has been adapted to the drawings. No one can really tell which.

Orthographic projection means perpendicular projection. It is called orthographic because the projectors are always perpendicular to the picture plane. This is a relatively abstract idea that, in theory, has no defining or restricting effect on what is drawn. However, in architecture, in practice, where it is tied up with other more obvious orthogonal relations, it does.

In architectural drawings the projectors are not only perpendicular to the sheet of paper but also perpendicular to the major surfaces of the building drawn on it. Buildings are often rectangular, so aligning their surfaces with the surface of the drawing seems a sensible thing to do; yet this convention of imaginative vision also helps *keep* them that way. Whether it does so like some sort of butter paddle or like some sort of rolling pin—whether, in other words, it makes buildings into blocks or sheets—it is a powerful, conservative, forming agency.

Dürer's fort is not a good example of this reciprocity between rectangular projection and rectangular subject-matter, precisely because it is more difficult and ambitious. Always the simplest thing to do is maintain the cubic format. One advantage of doing so is that it renders projection so easy to the seasoned practitioner that he is no more conscious of the viscosity or refraction in this medium than a fish is conscious of water.

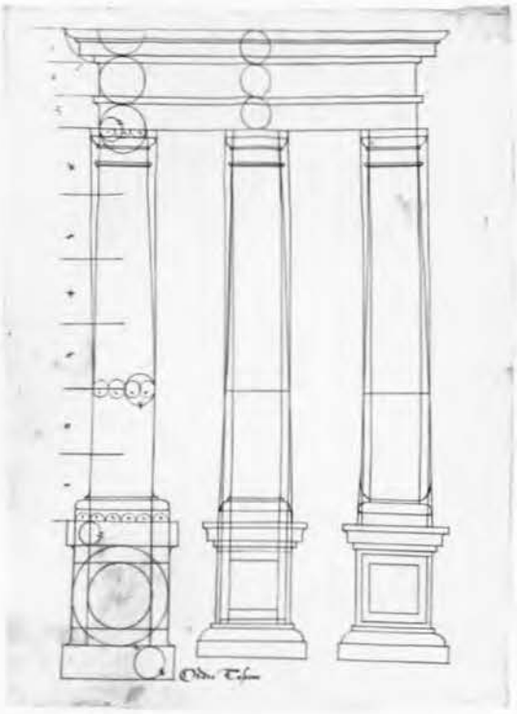
The next examples, taken from an album of drawings attributed to Jacques Androuet Du Cerceau, do, to some extent, show this easy relationship, in a less technically demanding use of projection. They are also from the sixteenth century, and one can see that the architectural implications of the technique were still being worked out; but they indicate very clearly that, even then, the architect's response to the drawing was to give in to it in some ways, and then to react against it in others.

Fig. 7. Workshop of Jacques Androuet Du Cerceau the Elder, *Arch in the Antique Manner* (between ca. 1565 and ca. 1585). Pen and black ink with black wash on vellum, 31.1 x 22.5 cm. CCA DR 1986:0108:017

Sets of plans, sections, and elevations describe aspects of buildings, and in describing them, give them constitutional privileges. These three types of drawing give us our priorities; other things can safely be assumed to follow. The Du Cerceau album, for instance, is made up almost entirely of front elevations, eighty pages of them (fig. 7; see cat. no. 114). Façades like these supply a prominent opening theme from which the rest of the project may either extend in consequence or hide behind. Most are far more frontal and far more axial than Dürer's fort. They go along with the drift of parallel projection, no difficulties are encountered, forms do not twist out of alignment with the page, unless easily handled, like the drums of columns and domes.

An alliance had already been struck between the abstractions of orthographic projection and the fundamental organization of classical architecture. With a subtlety bordering on subterfuge the drawing technique conferred properties on its subject; rectangularity, planarity, axiality, symmetry, frontality. As painting after the Renaissance was overwhelmingly perspectival, so architecture after the Renaissance was overwhelmingly orthographic.[14]

The Du Cerceau drawings indicate three ways



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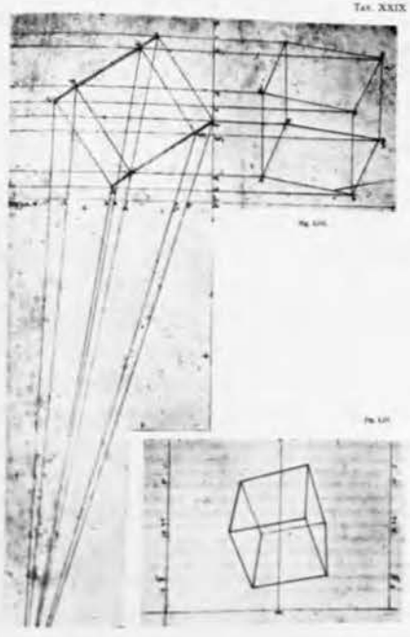

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Fig. 8. Workshop of Du Cerceau the Elder, *Three Tuscan Columns* (between ca. 1565 and ca. 1585). Pen and black ink with black wash on vellum, 31.1 x 22.5 cm. CCA DR1986:0108:001

Fig. 9. Piero della Francesca, *Orthographic and Perspective Projections of a Cube*, plate XXIX from *De Prospectiva Pingendi* (facsimile edition of ca. 1480s). Offset lithograph, page 24.0 x 17.1 cm. CCA 1D85–B9792.

Fig. 10. Workshop of Du Cerceau the Elder, *The Façade of a Lodging* (between ca. 1565 and ca. 1585). Pen and black ink with black wash on vellum, 31.1 x 22.5 cm. CCA DR1986:0108:015

out of this immensely stable relation between medium and form. Some of the drawings in the album are pure orthographic elevations, but many are not. They include illicit indications of aspects that should properly be hidden. Sides and undersides are made visible, jutting out from the planar façade surface to show projections and recesses. These have usually been added in such a way that they do not disturb the overall unity of the drawing. They do not compromise the planarity of the façade surface, but push and pull it into a thin slab of perspective space, no less frontal than pure elevation.

Closely associated with this technique is the addition of wash shadows inside the ink outlines. The first ten sheets of the album, which show the five orders with no deviation from pure orthographic projection, and with no added indication of shading (fig. 8), may be compared to the façades in the rest of the album: the former look bodyless, the latter, corporeal. This kind of shading had been developed in tandem with perspective during the fifteenth century. Transferred to orthographic drawing, it has the odd effect of adding precisely what had been taken away by that type of projection. It is very strange, I think, that when any prismatic solid, out of alignment with the picture plane, is drawn in orthographic projection, it is quite hard to tell the resulting figure from a perspective. Piero della Francesca's central and parallel projections of skewed cubes demonstrate this ambiguity well (fig. 9).[15] It is only when the parallel alignment of prism and sheet is established that orthographic projection *looks* so different from perspective. It looks more reticent, more abstract, flatter, muter. The introduction of shading restores what was lost. Once again the effect approaches that of perspective. Perhaps the most accomplished drawings of this type from the early period are Antonio da Sangallo the Younger's sections and elevations of his project for St Peter's made in 1520–1521.[16] Other examples include the late-seventeenth-century elevation/section of Santa Maria della Steccata, in Parma, attributed to Mauro Oddi (cat. no. 6); Marchionni's 1776 sacristy project for St Peter's, Rome (cat. no. 7); and Antoine's fountain design from 1752 (cat. no. 9).

Finally there is, in the Du Cerceau façades, a tendency to move emphasis from the centre to the ends of the symmetrical piles of building. The central cut normally made by the section would tend to make the middle the most emphatic, because the most fully described, part. The axial organization of much post-Renaissance architecture is facilitated by this technical convention. Accordingly, most "correct" classical façades tend towards an aBa rhythm, whereas the Du Cerceau compositions tend to be AbA. This happens across the whole façade, and also in miniature within individual pavilions and bays, to such an extent that the normative three-part structure is transfigured into a two-part structure joined by a hyphen (fig. 10). The album therefore provides a surprising example of centrifugal composition, identified by the architectural historian Emil Kaufmann as characteristic of eighteenth-century Neoclassicism.[17] This same collection of façades all but turn the tripartition, identified by two more recent authors (Alexander Tzonis and Liane Lefaivre) as the essential structure of classicism, into bipartition.[18] I do not say this to show that these scholars are wrong; I include it as an example of the way liberties were taken with the normative *schema* that was not just classical but *orthographic* and classical.

These three ways out are very different. Their combined presence suggests that while the norms of classical composition may have been supported by the conventions of architectural drawing, architects never conceded everything to the alliance. They would always do something more; they would always extricate themselves. Not that they were trying to effect means of escape; as one aspect was challenged or denied, another would be adhered to all the more closely. To push one thing you need to pull another. A system like this provides sufficient traction for such manipulation to take place.

Next to be considered is an example of a type similar to the last. It reinforces the point that classical architecture was not architecture that followed straight from principles, nor even architecture that played within the limits of a broader system, as a child might play in a garden, but was rather an architecture the most exquisite characteristics of which derived, as often as not, from contrary ideas, thoroughly at variance with the principles upon which the whole edifice of classicism was presumed to rest. This may seem an inappropriate place to make such a sweeping claim, but the reason for making it is to show, again, how the drawing technique became the agency for the taking of liberties–liberties of an ingenious and subtle kind that were highlighted in this medium alone, nothing ever being written about them.

Bertrand's *Ombres d'un chapiteau Toscan* (1817) is school work, from the École des Beaux Arts, Marseilles (fig. 1). Drawings of details of the classical orders were not only produced in quantity within the academies as part of the teaching program but were also the stock-in-trade of publishers. Descriptions of the five orders form a large part of architectural literature from the early sixteenth century to the nineteenth. The major authors devote either individual works to them or major segments of their major treatises. It is difficult to find exceptions; even an improbable candidate like Guarino Guarini, architect of buildings that hardly fit into the classical category, did so.[19] The orders have the advantage of providing, at one and the same time, the most general and the most particular information about a classical building, from the shape and size of its tiniest moulding to the distribution of its largest parts. Books on the orders were vastly influential in spreading classical ideas throughout Europe and beyond, changing western architecture while giving it a more uniform complexion.

Because of this, we might conclude that Bertrand's drawing represents the most stolid, the most rule-bound, the most circumscribed, the most didactic, the least vivacious aspect of the Antique/Renaissance tradition. We might even compare it unfavourably with earlier illustrations of the same sort, either printed versions in the works of G.B. Vignola (fig. 11), Philibert De L'Orme, Bertotti Scamozzi, and John Shute, or early drawings like those in the sketchbook of an unknown architect made between 1520 and 1550 (cat. nos. 34.1–34.5). It could be said that these at least maintained some freedom of execution, where, by

Fig. 11. Giacomo Barozzi da Vignola, *The Tuscan Order*, page 1111 from *Regola delli cinque ordini d'architettura* (1562). Engraving, plate 35.0 x 20.8 cm. CCA WM3245 TR/VI

contrast, the nineteenth-century school drawing was entirely determined by measurement, dessicated by it. The difference is particularly noticeable in the treatment of shadows.

In earlier drawings shadows are sketched in intuitively, the designer calling on his powers of observation and memory to tease out the form, whereas Bertrand relies entirely on shadow projection (sciagraphy). The exact lines of the cast shadows result automatically, once the position of the light source has been chosen. Are we to conclude, then, that through

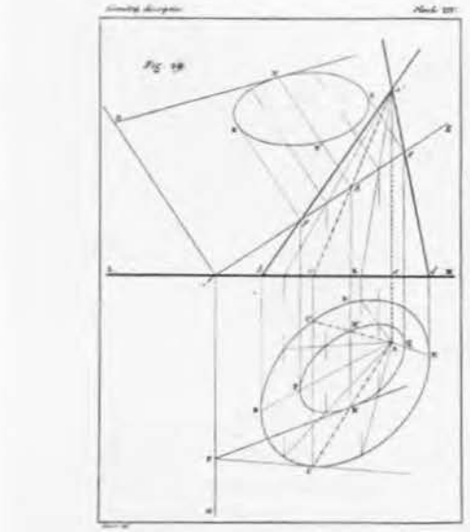
Fig. 12. Brochier the Elder, *The Roman Doric Order* (1823). Pen and black ink, black ink wash, and graphite on laid paper, 60.7 x 41.5 cm. CCA DR1979:0027:001 (cat. no. 29.2)

this exercise Bertrand was being taught to trust the mechanical procedures of projection rather than to trust his own powers of observation? This does not seem an unreasonable inference. The comparison between Bertrand and Vignola might be regarded as unfair, because Vignola's illustration was concerned with the column, whereas Bertrand was concerned with shadow-projection, using the capital merely as a convenient working surface to throw this information across. But the fact is that during the late eighteenth and nineteenth centuries a larger and larger portion of all illustrations of the orders were like Bertand's – and like Brochier's slightly later example of the whole Tuscan order from the same school (fig. 12) – drafted with the utmost precision, either tinted with carefully laid washes that simulate the smooth modelling of exquisitely dressed masonry in strong glancing light, or engraved to similar effect. Through these studies architects were made more fully aware of the constitution of classical elements.

Several writers have recently suggested a connection between the development of what is called descriptive geometry, teaching methods in schools of architecture, the more pervasive use of projection, and the rationalization of architecture.[20] Descriptive geometry was the brain-child of Gaspard Monge,[21] a military engineer, mathematician, and practical scientist who rose to prominence during the French Revolution, and who, favoured by Napoleon, was able to push through a radical reform of technical education. He was co-founder, in 1795, of the École Polytechnique in Paris, the model for *polytechnique* institutions throughout France, in which architecture was taught side by side with engineering and industrial skills. Only one subject was common to all the courses: mathematics.

Descriptive geometry is a mathematically rigorous formulation of a set of rules, the acceptance of which makes it possible to describe any conjunction or intersection of geometrically consistent forms in space, with a minimum of information and a minimum of construction. It also involves parallel projection perpendicular to the picture plane, and could be described as a more powerful, more abstract, more generalized version of architectural drawing. It was first taught in conjunction with architecture in the *écoles polytechniques*, and was later added to the curriculum of many other schools.[22]

There are discernible traces of Monge's descriptive geometry in Bertrand's sciagraphy for a Tuscan capital. Monge required only two projections for even the most complex task. Descriptive geometry was not



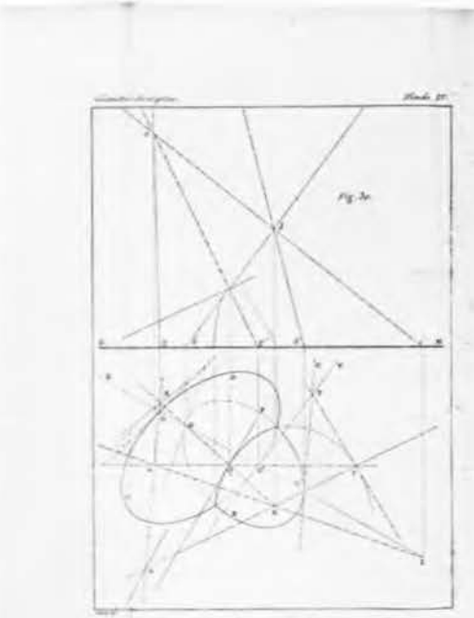


Fig. 13. Gaspard Monge, plates XIV and XV from *Géométrie descriptive* (7th ed. 1847). Plate XIV, etching, 21.8 x 16.6 cm; plate XV, etching, 21.8 x 16.6 cm. CCA PO 12033

concerned to show what things were actually like; it was concerned only to determine relations between geometrically defined bodies and surfaces. Monge demonstrated that this could be accomplished with reference to points and lines and nothing else. And so the bodily constitution of things drawn disappears. Often, all that is left is a confusing web of dotted and solid lines, many of which are imaginary, bearing no immediately obvious formal relation to the object represented (fig. 13). Because there are only points and lines, everything is rendered transparent. And this is why only two projections are required; so long as you know how the projection is made, two points on two surfaces will determine a third, unique point in space from which they were projected. The fundamental set of drawings in descriptive geometry is therefore quite different to that of architectural drawing. For convenience the two planes of projection, called *reference planes*, are perpendicular to one another, but they do not have to face what is drawn. Monge's system did away with frontality as well as substance.

As can be seen in Bertrand's drawing, the new system could nevertheless be adapted to architectural use. If you imagine the drawing folded up along the horizontal line dividing the elevation of the capital from the half-plan, so the plan would be at right angles to the elevation, you will see at once that the capital, or rather half of it, would fit into the fold. This fold line is very important in descriptive geometry because it holds the two representations in a fixed relation and can be used to great advantage. But no use of it is made in this instance; here we have the format of Monge's system without its full exploitation.

The tracing of the shadow lines is done with the aid of a series of vertical sections through the capital, cut in slices parallel to the direction of the sunlight. The technique is similar to Dürer's slicing of the cone (see above). Having mapped these oblique section lines from the plan into the elevation of the capital, it is possible to find the play of shadows on the double-curved surfaces. The sunlight, shining down at a certain angle (represented by the slanted parallels [pink in the original] cast down from the abacus and astragal), makes tangents to the section lines through the double-curved surfaces. Above the line of tangency the column is in sunlight; below it, in shadow. Join the points of tangency and you get the shadow line. The process is most easily understood by looking at the astragal moulding at the top of the shaft.

So even if this is not a consummate example of Monge's descriptive geometry, it is an example of the more complete determination of architectural drawing by geometrical means. It might be argued that the play of sunlight on stone is not materially affected by the way we draw it. Unlike the design of the classical orders themselves, it is merely a simulation of what might happen after something is built. This, however, is the reason these drawings are so interesting. The after-effect is more vividly portrayed than the shape of the capital itself. Now, apart from any argument about "scientific" drawing being a symptom of a modern malaise, as some writers tell us it is, another point might be made: this encroachment of geometry into territory more usually reserved for intuitive judgement brought out certain intrinsic characteristics of classical architecture, never before or since displayed so clearly.

There is something a little forbidding, it is true, about the combination of two such authoritative kinds of knowledge in one drawing. The authority of the classical orders and the authority of geometry leave no space between them for anything else. This then is surely the point at which the argument should be conceded to the critics cited above. Yet while we would expect the integration of cultural norm and mathematical truth to yield a product both unassailable and moribund, this is not the result, or so at least it seems to me.

I would explain it as follows: it has to do with the way mechanical structure is illustrated in one way and simultaneously contradicted in another. The classical orders developed out of a structural system of columns and lintels. If one *desideratum* for a treatise on architecture was a description of the five orders, another was an explanation of the origin of building from the primitive hut. The archetype of our way of building was the Greek temple, and the precursor of the Greek temple was a rude dwelling of timber. Decorative features in stone buildings that had no obvious utility were traced back to timber constructions, and so legitimized. The historical truth of this interpretation of some if not all elements of classical building is difficult to assess.[23] But its very existence as an explanation brings out a bizarre feature of classical architecture. A structure is shown not only for what it *is*, but for what it *was* on top of what it *is*. Does this not intimate an obsession with stability?

Particularly well furnished with recollections of wooden construction are the areas round the top and the bottom of columns. The complex details of torus and plinth, and of astragal, echinus, and abacus, refer to the hoops and pads once necessary to protect these vulnerable points, for it is a fact that any structure made from separate columns and lintels will tend to fail around these joints. They are the weakest parts. The first thing written of the Tuscan column in the first book to display the orders as a set (by Serlio) is this: "We find in Antiquities, and also in modern works, many pillars or columnes, which beneath in the joynts at the bases are broken asunder."[24] So the rhetorical elaborations of capital and base would seem to be in complete accord with the real structure of the building. They provide a reassurance in sign language that the structure is indeed safe and sound; that the parts in most need of strengthening have been properly held, fixed, and made fast against the possibility of collapse.

The sturdy Tuscan order not only stands firm but insists on *signifying* that it does so.[25] There is, however, a third layer of structural interpretation on top of these two, one that has always been visible, though it has not, as far as I know, been discussed at all. It is this third structural sense that is flaunted in the rote exhibition and studio drawings from the academies and polytechnics. Look once again at the Tuscan capitals of Bertand and Brochier. The shadows, precise as they are, dissolve the structural form. They do so by superimposing a derived pattern, a projection within a projection, which throws one

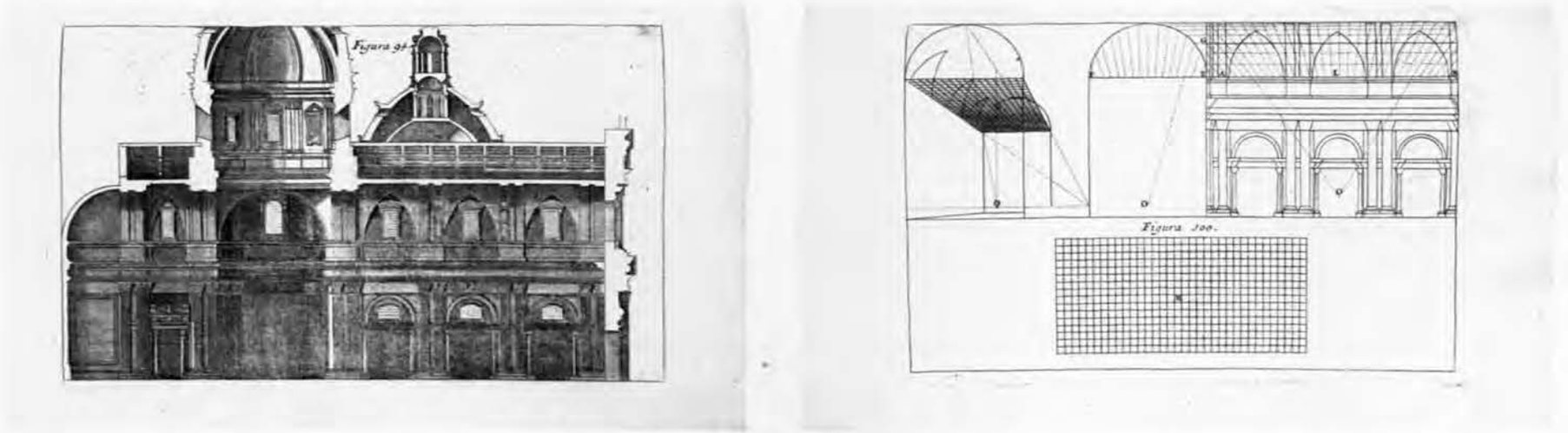


Fig. 14. Andrea Pozzo, *Method for Projecting Plane Perspective Pictures into Vaults*, figures 94 and 100 from *Perspectiva pictorum et Architectorum* (1711). Figure 94, etching, plate 16.4 x 27.4 cm (page 20.4 x 33.4); figure 100, etching with burin, plate 16.8 x 25.0 cm (page 20.4 x 33.4). CCA WX9038:1

contour of the simplest of capitals against its own curved surfaces. Shadows are insubstantial and impermanent. Their properties are exactly opposite to the properties of the column they glide across. The one thing they share, in this instance, is the frozen sharpness of geometric delineation; the indication of a strong sun held in the sky. And strangely enough it is this one shared characteristic that allows the shadow to take its revenge on the stable column.

The shadows on Vignola's Tuscan column were added in a painterly way to enhance our perception of the rotund but simple shapes that might otherwise have escaped attention in the orthographic outline. By complete contrast, the simple forms of Brochier's Tuscan column, all made from straight lines and arcs of circles, are eaten up by shadows–not along the shaft of the column, but at its extremities, at the points of greatest stress. Overlaying and obscuring the clear recognizable geometry and the clear recognizable signs are the distended curves, the sloping lenticular highlights, the sharp, disoriented, flexed triangles: ghosts that come out in good weather to turn the double signification of classical stability into a disruptive gyration of glancing lines. Nor is this an illustrator's whim. Columns *are* threatened and animated by strong sunlight. But the effect, which is among the most beautiful and subtle in architecture (as well as among the most common), is not of instability: rather it allows the observer to imagine the structure as quickened instead of deadened at its crucial points. These laboured school drawings show us how light can obscure one kind of meaning and supply another–something that was not in the curriculum.

The projected drawing is, it should be said, no more a liberating agency than is classicism, and countless cases from different periods could be cited to show that it may be restrictive and confining. The conclusion that may nevertheless be drawn from the preceding examples is that it is not necessarily that way. It would be possible to treat, say, the drawings by Ernst May and Gustav Hassenpflug of rationalized housing (1932) as a contrasting example, where the format of the projection engenders a restrictive economy of form within the architecture that it represents (see cat. nos. 42.1–42.4). The result, however, is utterly unsurprising. Instead of looking in the most obvious place to find what we are looking for, it may be more instructive to look in a less likely spot. The apparently unregulated freedom exhibited in the *quadratura* designs of the Baroque and Rococo periods also betray evidence of an orthogonal order conferred on the designs by means of projection, though not as easy to discern as in May's and Hassenpflug's work.

Drawings by *quadratura* painters from the seventeenth and eighteenth centuries vary greatly in quality, but the best of them are virtuoso sketches, full of flair and vitality even though they were intended only as preliminary cartoons. *Quadratura* artists were commissioned to work on a building once the architectural shell was completed. They therefore had the advantage of surveying the architectural effect *in situ*, thus enabling the painter to get a clear idea of the often complex envelope of surfaces that he was going to have to treat as a picture plane.

By the late seventeenth century perspective had been well assimilated throughout Europe, and was studied by all painters as a matter of course. From the 1630s onward there appeared technical treatises that dealt not only with the projection of perspective images onto a frontal, flat plane of the kind generally favoured by artists, but onto a whole variety of other surfaces: inclined, spherical, cylindrical, and conic.[26] A connection exists between the knowledge pro-

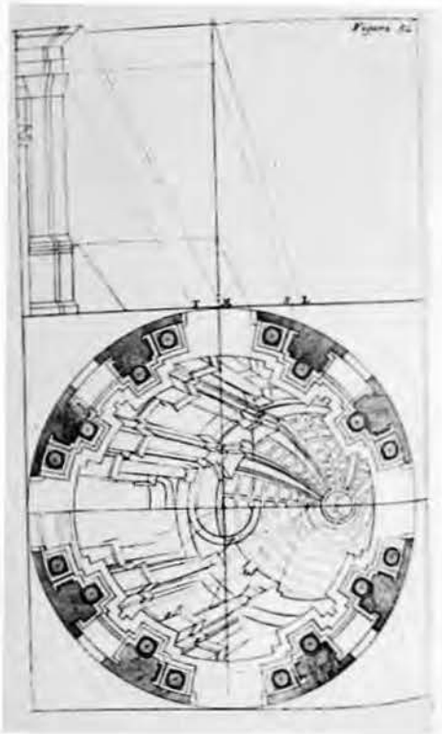


Fig. 15. Pozzo, *Plane Perspective View into a Dome*, figure 52 from *Perspectivæ pictorum atque architectorum* (1711). Etching, plate 28.5 x 18.0 cm. CCA 00083320

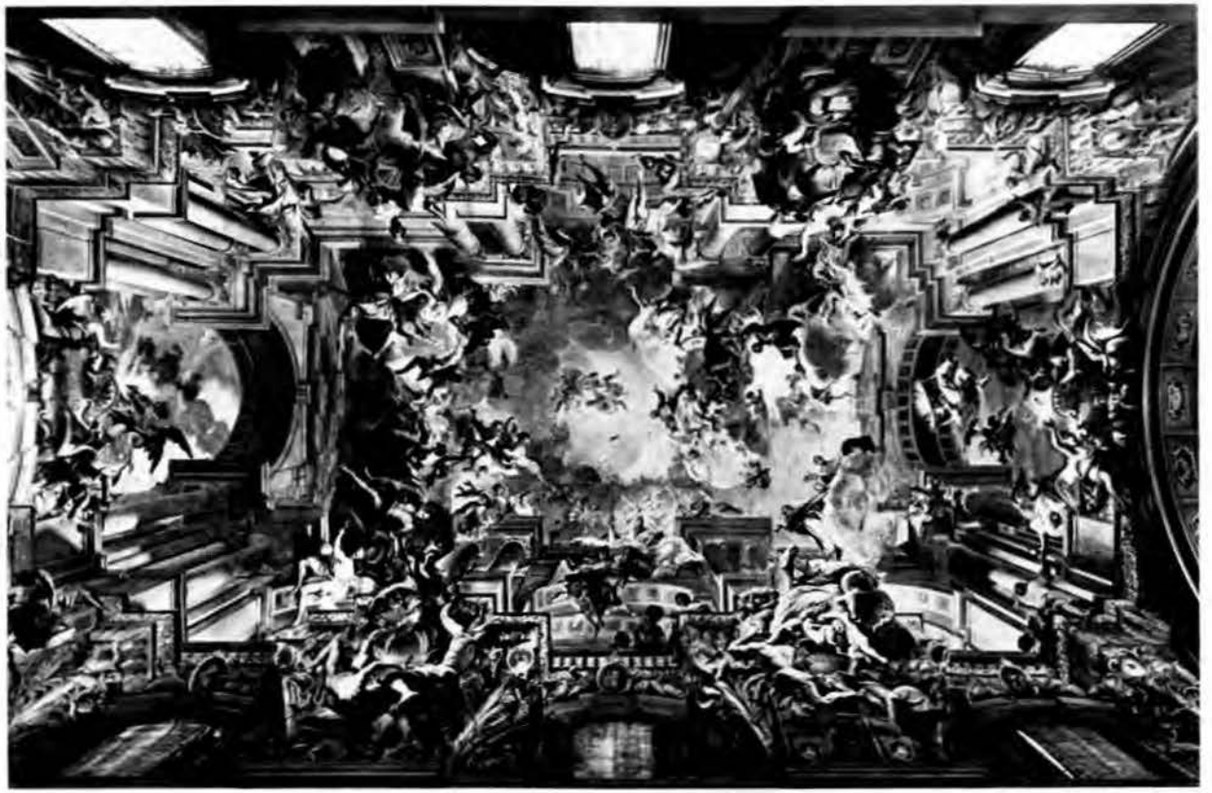


Fig. 16. Pozzo, *Allegory of the Missionary Work of the Jesuits: Nave Vault of Sant'Ignazio, Rome* (between 1691 and 1694)

pounded in these treatises and the stunning perspective virtuosity of the frescos; but it is not as direct as all that. The treatises were mostly transalpine (Dubreuil, Desargues/Bosse, Niceron, De Caus), while the leading *quadratura* painters were mostly Italian. This was not an insuperable barrier. Andrea Pozzo, the greatest of them, responsible for the vast and vertiginous Jesuit Allegory on the vault of Sant'Ignazio, Rome, published a masterly work on perspective in 1693. It was available in English translation by 1707, with an introductory commendation from Christopher Wren, John Vanbrugh, and Nicholas Hawksmoor.[27]

In this book, Pozzo describes his method of projecting an image onto a vault; it was the method suggested by Desargues fifty years earlier.[28] A net of cords in a square grid is strung at cornice level below the vault (fig. 14). A viewing point near the floor is chosen. Then, either a light is fixed here and the projected shadow of the grid traced onto the undulating vault above, or the same result is obtained with another cord, from the fixed viewing point, stretched up to touch the cords of the grid and onward, until it meets the ceiling where the alignments are marked. This is a variant of Dürer's technique for mapping perspective outlines with cable and cursor, only this time the information is being transmitted in the opposite direction, from two dimensions to three. The method is very physical and not very theoretical. It means that the design of a fresco can be undertaken without reference to the complexity of the surfaces upon which it will be painted. The rest of Pozzo's treatise is therefore confined to conventional plane perspective, even if, sometimes, the view is upward rather than horizontal (fig. 15). In practice it allowed Pozzo to paint the vault of Sant'Ignazio (1691–1694) so that the undulations of the intersecting severies are completely obliterated by the perspective when viewed from the centre of the nave directly below (fig. 16). In place of the vaguely medieval outline of the severy intersections, he painted an illusionistic extension of the classical orders into the heavenly vortex. The victory of perspective space over real architec-

Fig. 17. Domenico Maria Canuti and Enrico Haffner: *Apotheosis of St Dominic: Vault of SS. Domenico e Sisto, Rome* (1674–1675)

tural space was, however, Pyrrhic. Viewed eccentrically the fresco turns into a complex anamorphosis of stretched, collapsed, and folded figures accentuating the observer's consciousness of how the vault distorts the picture, and, more interesting still, how it distorts the fictional space intimated by the picture. Nevertheless, these effects are achieved mechanically; an identical result would be obtained by taking a transparency of a plane-perspective picture and using a projector to put the image into the vault.

Not long before, another ingenious *quadratura* artist, Enrico Haffner, working on a similar vault in Santi Domenico e Sisto (1674–1675), chose to treat the unclassical distended curvature of the severy intersections as the framing for a billowing and distorted architectural fantasy (fig. 17).[29] An enterprise like Haffner's presumably required a mixture of work devised *in situ* (around the severies) and projection (for the arches painted across the remaining part of the nave barrel vault). It could not easily have been accomplished by Pozzo's method alone. But if *quadratura* artists used the encompassing, overriding projection technique described by Pozzo, which was not responsive to circumstances, and also adapted to the architectural shell, how did they manage to combine these two very different and apparently incompatible ways of working?

Flaminio Minozzi's drawings, although much later, give some inkling of the way such painters could visualize and design the complicated interactions between a real space and the imaginary space they superimposed upon it. An unattributed drawing, perhaps Minozzi's, shows a door-case inside a sumptuous Serlian frame (fig. 18). The drawing adopts a convention, quite common in *quadratura* designs, whereby part of a wall and a part of an adjacent ceiling are shown as one continuous unfurling of space on a flat sheet of paper. The curve between the vertical and diagonal lines at the left-hand edge of the design signifies a modest coving.

The door-case and the Ionic columns around it are shown in oblique perspective (that is, a frontal view with the vanishing-point far over to one side, in this instance to the right). The question is: Does the drawing indicate real columns or painted columns on a flat wall? The probable solution to this difficult question, which should necessarily arise from our inability to tell an effective illusion from an effective representation, is to be found in the tympanum above the door, the whole area of which is drawn as if seen squarely from the front, except for the miniature keystone, at the very top, which begins to lean over to the left, implying, once again, that the observer is looking at it from the right-hand side. Above this, the perspective tips backward (upward) as it passes across the coving, and shifts decisively to accommodate a point of view, again, far to the right and vertically above the vanishing point for the Ionic columns.

On the ceiling the architecture is most certainly illusionistic. On the wall it is probably not, for the following reason: if it were illusionistic, the draughtsman would have treated it in the same way he treated the tympanum. He would have shown it from the front, to avoid the offensive inconsistency that would be glaringly obvious as one walked toward the door. In all likelihood this drawing represents the corner of a large room as seen from the centre. From this privileged position both real and illusionistic architecture are in consistent perspective. The only aberration is the adjustment made to soften the effect of distortion that becomes more and more evident as the oc-

Fig. 18. Unknown artist, *Quadratura Drawing for Door-Case and Surround* (between 1675 and 1725). Pen and brown ink and brown wash over black chalk, 54.2 x 40.3 cm. CCA DR1960:0021

cupants approach the perimeter of the spacious interior, especially toward the doors.

Minozzi's design for the painting of the Capella del Santissimo in San Giovanni in Monte, Bologna, was constructed in similar fashion, although in this case, two adjacent walls are folded out into a single plane, while the vault is developed in a broad strip extending from the wall behind the altar (fig. 19). The perspective in the soffits of the two arches above the cornice indicates that Minozzi was imagining the chapel from a point just inside the entrance, facing the altar. The only other indication of a correlation between these two arches is in the section through the moulding at the head of the arch, visible at the left-hand edge of the strip, as if the unfolded arch beside it had been folded back into place–which would suggest that the drawing, up to that level, is orthographic. The treatment of the transition between the arch and the octagon drum above renders this reading implausible, however. It is impossible to say, from the drawing, exactly what space it refers to; but it is possible to say that the drawing *must* be mule-like and mixed: it cannot be read as orthographic projection, development (the laying out of faceted or curved surfaces into a flat plane), or perspective, or any consistent containment of any one of these in any other.

The format of these *quadratura* drawings shows the painters thinking out their work, always contextual, in terms of unfolded orthogonal surfaces, closely identified with the real architectural shell, but not necessarily identical with it. In other words, they carried in their minds a perspective box from which a sequence of flat pictures would be transmitted to the surrounding walls and vaults. Pozzo's procedure of

Fig. 19. Flaminio Innocenzo Minozzi, *Design for the Decoration of a Chapel in San Giovanni in Monte, Bologna* (between 1780 and 1790). Pen and brown ink with brown and grey wash, over graphite on laid paper, laid down on wove paper, 41.5 x 30.3 cm. CCA DR1962:0005 (cat. no. 14)

mapping was a rationalization of this procedure. The Minozzi drawings show the same format engaged with, and modified by, the shapes and circumstances of specific interiors.

I HAVE DEALT thus far with orthographic projection, and to a lesser extent perspective, during the period dominated by classicism. There is no doubt that the essentials of contemporary architectural drawing were mapped out then. What of modern architecture? Should we not expect to find it in mortal combat with these inherited techniques? Perhaps, but it was not that way at all. The question, as far as I am aware, was never raised. Questions of drawing were raised, but not questions of projection. Whereas in painting vigorous attempts were made by Cubists, Futurists, Suprematists, and Constructivists to destroy the shibboleth of perspective,[30] and whereas, in architecture, various other reminders of past practice were under attack–ornament, Art, stone, etc.–no such campaign was mounted against orthographic projection, which remained the inviolate medium of architectural thinking.

There have nevertheless been at least two significant changes in drawing practice during this century: the increasing prominence of axonometric projection, with its subsequent incorporation into the conventional set of architectural drawings; and the more frequent resort to, and greater investment in, the sketch. Neither is universal, yet both warrant attention.

The sketch is a peculiar phenomenon. It is impossible to decide, except by dogmatic means, whether it is a projection or not. In so far as it is like a scale drawing, it is projective; but its capacity to absorb so many other interpretations, to be whatever one wants to see in it, and to multiply ambiguities and inconsistencies, make it work quite differently. So it would not be right to classify it as an imprecise approximation of a projection. Its relation to its object is far more uncertain than with the drawings discussed so far, being more a matter of suggestion than designation. And this is why its increased prominence is significant. The sketch has become a way of holding

back, keeping everything in a state of suspension, of refusing to give in too quickly to the *parti*, a way of staving off the fixation of a particular figure or shape. The metaphors most frequently applied to the sketch are those of conception, gestation, and birth. Its amorphous, unformed, embryonic character is what distinguishes it. Louis Kahn's sketches for a Congress Hall, some of which are more like smudges than drawings, show to what extent line and figure may be held in abeyance that way (cat. nos. 135.1–135.3).

It is true that different architects use the sketch in different ways. The expressive sketch is familiar enough, where an essential feeling is recorded in a dynamic calligraphy; and the ensuing architecture tries to follow the original trace as closely as it might, suggesting that all inspiration had been released and captured in the first few seconds. Mendelsohn worked this way in his early career. The drawings by Poelzig for the Grosses Schauspielhaus, Berlin, are also of this sort (cat. nos. 133.1–133.5). Kahn's are not. His sketches mutated quite suddenly into something else. Out of the blurred charcoal and the cryptic ciphers a complete configuration would crystalize. The model of the Congress Hall shows the same project in this other, suddenly definite shape (cat. no. 135.4).

There is no real evidence that the clear configuration was born out of the indefinite sketch. If anything the evidence leads in the opposite direction. When Kahn later described his first idea for the Congress Hall, he described it as a geometric configuration, much as is found in the completed scheme.[31] Underneath the blackness of the sketch is the same obfuscated figure. It was already there. Moreover, while the numerous *pentimenti* in the architectural sketches of Michelangelo and Borromini were used to modulate and modify forms, the form in Kahn's sketch undergoes no obvious variation.

Kahn's fascination with and exposition of the unmeasurable aspects of architecture are well known, and that is exactly the property that marks the sketch out from other forms of architectural drawing; its incommensurability. It seems that the sketch was, for him, an illustration of the way order emerges from chaos, more than a divining instrument for finding it. It was the sign for, rather than the location of, creativity. It was only incidentally a propedeutic device, and yet gave proof that Art was afoot. I suspect that it was also a constant reminder of a principle that Kahn felt he had to repeat over and over again (to himself or others?): that the commensurable order of architecture, so overwhelming in his buildings, was only a way to achieve incommensurable effects. He was careful to preserve his sketches, and happy to publish them.

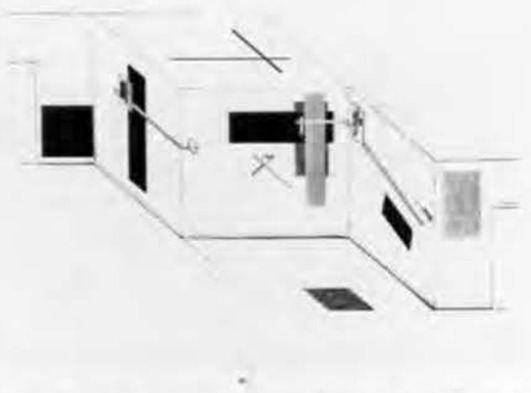


Fig. 20. Eleazar Markovich Lissitzky, *Axonometric Projection of the Proun Room Installed at the Greater Berlin Art Exhibition* (1923). Lithograph on wove paper, 44.3 x 59.9 cm. CCA DR1984:1581 (cat. no. 16)

The complementarity between geometric and atmospheric states of drawing is easier to describe than to explain. It seems to be something peculiar to Kahn's method of working. And yet the broader development of twentieth-century architectural drawing shows a divergence toward similar extremities. For if the sketch has obtained greater prominence, so too has the axonometric projection, and the axonometric is, of all forms of projection, the one most confined within its own geometric definition.

The claim has been made, notably by Yve-Alain Bois, that the axonometric, in the hands of Lissitzky and van Doesburg, enabled these artists to devise a new kind of space proper to the twentieth century.[32] Lissitzky's lithograph of the *Proun Space* constructed in Berlin in 1923 is a crucial element in this story (fig. 20). An immensely sophisticated mixture of development and axonometry allowed him to portray all six surfaces of the room with a minimum of rupture (the two loose ends, each with half a doorway, have to be imagined as folding round behind the observer to join together). He did this by exploiting the ambiguity of spatial registration characteristic of axonometric (and isometric) projection, so that we look *up* into the ceiling and the left-hand wall joined to two sides of the central wall, and *down* into the floor and the right-hand wall joined to the other two sides of the central wall. Ambiguity, which had previously been regarded as a failing in this type of projection, was now being put to positive æsthetic use. The spatial qualities intimated in Lissitzky's Prouns and Doesburg's counter-compositions were undeniably new. The problem then faced by both these painters who had turned towards architecture was not so new, although it was presented with unusual force in their work. How is it possible to convey the properties so powerfully present in architectural drawings into the constructions they represent? Such transmission is possible, but in as much as it refers to ambiguous and fluctuating spatial registrations, it is not. This kind of fluctuation cannot be directly transmitted into three dimensions. That is why, in Hejduk's drawings for the NEWS House (cat. nos. 12.1 – 12.5), the further elaboration of a similar species of ambiguity keeps the project firmly on the surface of the paper.

Notes

1. Marcel Jean, *The History of Surrealist Painting*, trans. S.W. Taylor (London: Weidenfeld and Nicholson, 1960), 76.

2. As for example in Juan Pablo Bonta, *Architecture & its Interpretations* (London: Lund Humphries, 1979), chaps. 2 and 3; and Beatriz Colomina, "Le Corbusier & Photography" (unpublished essay).

3. Robert Branner, "Villard de Honnecourt, Reims and the Origin of Gothic Architectural Drawing," in *Gazette de*

Beaux Arts (Paris/New York), 6th series, LXI (March 1963), 129–146.

4. Even now, some space is retained for him on several counts. See Carl B. Boyer, *A History of Mathematics* (New York: John Wiley, 1968), 324–327.

5. Marshall Clagett, *Archimedes in the Middle Ages* (Philadelphia: American Philosophical Society, 1980), IV, pt. 1 ("A Supplement on the Medieval Latin Traditions of Conic Sections"), 266–267.

6. Piero della Francesca, *De Prospectiva Pingendi*, ed. G.N. Fasola (Florence: G. C. Sansoni, 1942).

7. Erwin Panofsky, *The Life & Art of Albrecht Dürer*, 4th ed. (Princeton: Princeton, 1971), 251–252.

8. Brunelleschi's construction is a matter of speculation, yet there is general agreement that the method found in the second part of Piero's treatise, using orthographic representations, was the most likely. Even Edgerton admits this, although it does nothing to establish his contention that the vanishing point was the key discovery in Renaissance perspective. See Samuel Y. Edgerton, *The Renaissance Rediscovery of Linear Perspective* (New York: Harper and Row, 1975), 130–132.

9. Peter Jeffrey Booker, *A History of Engineering Drawing* (London: Chatto and Windus, 1963), chaps. 5–7, 37–78.

10. Gaspard Monge, *Géometrie Descriptive* (Paris: Hachette, 1799).

11. Massimo Scolari, "Elementi per una storia dell'axonometria," in *Casabella*, 500 (1984), 42–49.

12. William Martin Conway, *Literary Remains of Albrecht Dürer* (Cambridge: Cambridge, 1889), 176–178.

13. The triumphal arch was published as a composite of engravings in 1515. See Albrecht Dürer, *Maximilian's Triumphal Arch*, ed. E. Chmelarz (New York: Dover, 1976). The monuments commemorating the suppression of the Peasants' Revolt are included in A. Dürer, *Underweysung der Messung* (Nuremburg, 1525).

14. The historical connection between the two kinds of projection, as well as their different impacts on architectural design, are investigated by Wolfgant Lotz, "The Rendering of the Interior in Architectural Drawings of the Renaissance," *Studies in Italian Renaissance Architecture* (Cambridge, Mass.: MIT, 1977), 1–41.

15. Piero della Francesca, *De Prospectiva*, tavola XXIX.

16. W. Lotz, *Studies*, 31–32; and Gustavo Giovannoni, *Antonio da Sangallo il giovane* (Rome: Centro Studi di Storia dell'Architettura, 1958), II, figs. 71–89.

17. Emil Kaufmann, *Architecture in the Age of Reason* (Cambridge, Mass.: Harvard, 1955), 41–47, 188–201, Kaufmann does not expressly state this as a principle, but it is implicit throughout the book.

18. Alexander Tzonis and Liane Lefaivre, *Classical Architecture: The Poetics of Order* (Cambridge, Mass.: MIT, 1986), 9–33.

19. Guarino Guarini, *Architectura Civile* (Turin, 1737), trat. 1.

20. Daniel Guibert, *Réalisme et architecture* (Brussels: Pierre Mardaga, 1987), chap. 2, 13–23; Alberto Pérez-Goméz, *Architecture & the Crisis of Modern Science* (Cambridge, Mass.: MIT, 1983), 279–285; Jacques Guillerme, "La tirannia dell' idealizzazione," *Casabella*, 520–521 (1986), 72–82.

21. P. J. Booker, *Engineering Drawing*, 86–106; and Daniel Bell, *Men of Mathematics* (New York: Simon and Schuster, 1965), 183–197.

22. P. J. Booker, "Gaspard Monge and His Effect on Engineering Drawing and Technical Education," *Transactions of the Newcomen Society*, 34 (1961–1962), 15–36.

23. Joseph Rykwert, *On Adam's House in Paradise* (New York: MOMA, 1972), 29–73.

24. Sebastiano Serlio, *The Five Books of Architecture* (London: Robert Peake, 1611), Bk. 1, ch. 1., fol. 8.

25. The insistence, commonplace in classical treatises, that architecture should be firm and at the same time express firmness, has been pointed out by Marc Grignon in "Pozzo, Blondel and the Structure of the Supplement," *Assemblage*, 3 (1987), 97–109.

26. Jugis Baltrusaitis, *Anamorphic Art*, trans. W. J. Strachan (Cambridge: Cambridge University, 1977).

27. Andrea Pozzo, *Perspectiva Pictorum et Architectorum* (Rome, 1693); English ed., *Rules and Examples of Perspective for Painters and Architects*, trans. John James (Greenwich, 1707).

28. Abraham Bosse, *Manière universelle de M. Desargues pour pratiquer la perspective* (Paris: Des-Hayes, 1648), 41–42.

29. Rudolf Wittkower, *Art and Architecture in Italy: 1600–1750* (Harmondsworth: Penguin, 1980), 333–334.

30. El Lissitzky, "A. and Pangeometry," in *Russia: An Architecture for World Revolution*, trans. and ed. E. Dluhosch (Cambridge, Mass.: MIT, 1970), 142–149, for instance. It is often said that the Cubist painters used multiple perspective, but the idea of obtaining true shape through some kind of equivalent of orthographic projection was clearly articulated at the time. See Edward Fry, *Cubism*, trans. Jonathan Griffin (London: Thames and Hudson, 1966), 53, 71, 77–78.

31. Louis I. Kahn, *What Will Be Has Always Been*, ed. R. S. Wurman (New York: Rizzoli, 1986), 53–54.

32. Yve-Alain Bois, "Metamorphosis of Axonometry," *Daidalos* (Berlin), 1 (1981), 40–58.