# I

"*Item Perspectiva ist ein lateinisch Wort, bedeutt ein Durchsehung*" ("*Perspectiva* is a Latin word which means 'seeing through.' "). This is how Dürer sought to explain the concept of perspective.[1] And although this *lateinisch Wort* was used already by Boethius,[2] and did not originally bear so precise a meaning,[3] we shall nevertheless adopt in essence Dürer's definition. We shall speak of a fully "perspectival" view of space not when mere isolated objects, such as houses or furniture, are represented in "foreshortening," but rather only when the entire picture has been transformed – to cite another Renaissance theoretician – into a "window," and when we are meant to believe we are looking through this window into a space.[4] The material surface upon which the individual figures or objects are drawn or painted or carved is thus negated, and instead reinterpreted as a mere "picture plane." Upon this picture plane is projected the spatial continuum which is seen through it and which is understood to contain all the various individual objects.[5]

So far it does not matter whether this projection is determined by an immediate sensory impression or by a more or less "correct" geometrical construction. This correct construction was in fact invented in the Renaissance, and although later subjected to

various technical improvements and simplifications, it nevertheless remained in its premises and goals unchanged to the time of Desargues. It is most simply explained as follows: I imagine the picture – in accord with the "window" definition – as a planar cross section through the so-called visual pyramid; the apex of this pyramid is the eye, which is then connected with individual points within the space to be represented. Because the relative position of these "visual rays" determines the apparent position of the corresponding points in the visual image, I need only draw the entire system in plan and elevation in order to determine the figure appearing on the intersecting surface. The plan yields the width, the elevation yields the height; and if I combine these values on a third drawing, I will obtain the desired perspectival projection (Figure 1).

In a picture constructed this way – that is, by means of what Dürer called a "planar, transparent intersection of all those rays that fall from the eye onto the object it sees"[6] – the following laws are valid. First, all perpendiculars or "orthogonals" meet at the so-called central vanishing point, which is determined by the perpendicular drawn from the eye to the picture plane. Second, all parallels, in whatever direction they lie, have a common vanishing point. If they lie in a horizontal plane, then their vanishing point lies always on the so-called horizon, that is, on the horizontal line through the central vanishing point. If, moreover, they happen to form a 45-degree angle with the picture plane, then the distance between their vanishing point and the central vanishing point is equal to the distance between the eye and the picture plane. Finally, equal dimensions diminish progressively as they recede in space, so that any portion of the picture – assuming that the location of the eye is known – is calculable from the preceding or following portion (see Figure 7).

In order to guarantee a fully rational – that is, infinite, unchanging and homogeneous – space, this "central perspective" makes two tacit but essential assumptions: first, that we see with a single and immobile eye, and second, that the planar cross section of the visual pyramid can pass for an adequate reproduction of our optical image. In fact these two premises are rather bold abstractions from reality, if by "reality" we mean the actual subjective optical impression. For the structure of an infinite, unchanging and homogeneous space – in short, a purely mathematical





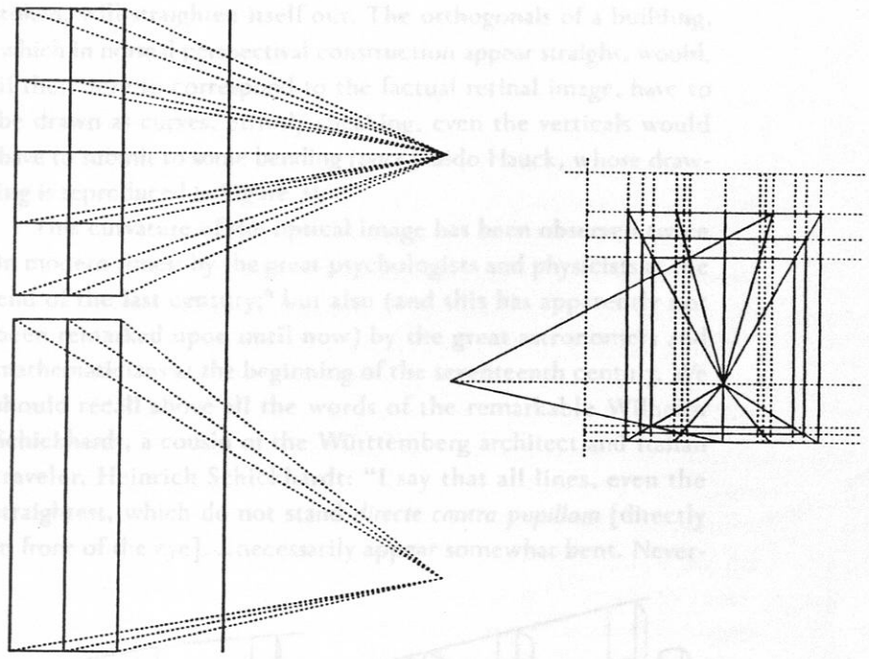


FIGURE 1. Modern "linear perspectival" construction of a rectangular interior space ("space box"). Left above: plan. Left below: elevation. Right: perspectival image arrived at by combining the segments marked off on the "projection line."

space – is quite unlike the structure of psychophysiological space: "Perception does not know the concept of infinity; from the very outset it is confined within certain spatial limits imposed by our faculty of perception. And in connection with perceptual space we can no more speak of homogeneity than of infinity. The ultimate basis of the homogeneity of geometric space is that all its elements, the 'points' which are joined in it, are mere determinations of position, possessing no independent content of their own outside of this relation, this position which they occupy in relation to each other. Their reality is exhausted in their reciprocal relation: it is a purely functional and not a substantial reality. Because fundamentally these points are devoid of all content, because they have become mere expressions of ideal relations, they can raise no question of a diversity in content. Their homogeneity signifies nothing other than this similarity of structure, grounded in their common logical function, their common ideal purpose and meaning. Hence homogeneous space is never given space, but space produced by construction; and indeed the geometrical concept of homogeneity can be expressed by the postulate that from every point in space it must be possible to draw similar figures in all directions and magnitudes. Nowhere in the space of immediate perception can this postulate be fulfilled. Here there is no strict homogeneity of position and direction; each place has its own mode and its own value. Visual space and tactical space [*Tastraum*] are both anisotropic and unhomogeneous in contrast to the metric space of Euclidean geometry: 'the main directions of organization – before–behind, above–below, right–left – are dissimilar in both physiological spaces.' "[7]

Exact perspectival construction is a systematic abstraction from the structure of this psychophysiological space. For it is not only the effect of perspectival construction, but indeed its intended purpose, to realize in the representation of space pre-





cisely that homogeneity and boundlessness foreign to the direct experience of that space. In a sense, perspective transforms psychophysiological space into mathematical space. It negates the differences between front and back, between right and left, between bodies and intervening space ("empty" space), so that the sum of all the parts of space and all its contents are absorbed into a single "quantum continuum." It forgets that we see not with a single fixed eye but with two constantly moving eyes, resulting in a spheroidal field of vision. It takes no account of the enormous difference between the psychologically conditioned "visual image" through which the visible world is brought to our consciousness, and the mechanically conditioned "retinal image" which paints itself upon our physical eye. For a peculiar stabilizing tendency within our consciousness – promoted by the cooperation of vision with the tactile sense – ascribes to perceived objects a definite and proper size and form, and thus tends not to take notice, at least not full notice, of the distortions which these sizes and forms suffer on the retina. Finally, perspectival construction ignores the crucial circumstance that this retinal image – entirely apart from its subsequent psychological "interpretation," and even apart from the fact that the eyes move – is a projection not on a flat but on a concave surface. Thus already on this lowest, still prepsychological level of facts there is a fundamental discrepancy between "reality" and its construction. This is also true, of course, for the entirely analogous operation of the camera.

If, to choose a very simple example, a line is divided so that its three sections *a*, *b* and *c* subtend equal angles, these objectively unequal sections will be represented on a concave surface (like the retina) as approximately equal lengths; whereas if projected on a flat surface they will appear, as before, as unequal lengths (Figure 2). This is the source of those marginal distortions

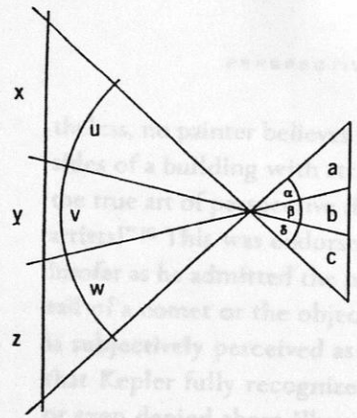



FIGURE 2. Explanation of the "marginal distortions."

which are most familiar to us from photography, but which also distinguish the perspectivally constructed image from the retinal image. These distortions can be mathematically expressed as the discrepancy between, on the one hand, the ratio of the visual angles and, on the other hand, the ratio of the linear sections produced by projection upon a flat surface. The wider the total or composite visual angle – that is, the smaller the ratio between the distance from eye to image and the size of the image – the more pronounced the distortion.[8] But alongside this purely quantitative discrepancy between retinal image and perspectival representation, which was recognized already in the early Renaissance, there is as well a formal discrepancy. This latter follows, in the first place, from the movement of the gaze, and in the second place, once again, from the curvature of the retina: for while perspective projects straight lines as straight lines, our eye perceives them (from the center of projection) as convex curves. A normal checkerboard pattern appears at close range to swell out in the





form of a shield; an objectively curved checkerboard, by the same token, will straighten itself out. The orthogonals of a building, which in normal perspectival construction appear straight, would, if they were to correspond to the factual retinal image, have to be drawn as curves. Strictly speaking, even the verticals would have to submit to some bending (*pace* Guido Hauck, whose drawing is reproduced as Figure 3).

This curvature of the optical image has been observed twice in modern times: by the great psychologists and physicists at the end of the last century;[9] but also (and this has apparently not been remarked upon until now) by the great astronomers and mathematicians at the beginning of the seventeenth century. We should recall above all the words of the remarkable Wilhelm Schickhardt, a cousin of the Württemberg architect and Italian traveler, Heinrich Schickhardt: "I say that all lines, even the straightest, which do not stand *directe contra pupillam* [directly in front of the eye]... necessarily appear somewhat bent. Never-

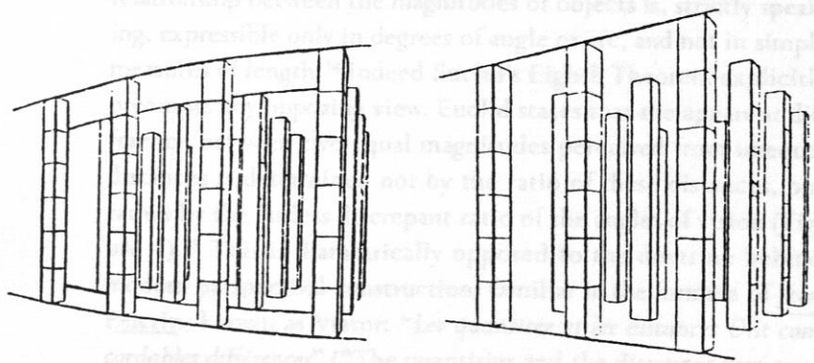


FIGURE 3. Hall of pillars constructed according to "subjective" or curved perspective (left) and according to schematic or linear perspective (right). (After Guido Hauck.)

theless, no painter believes this; this is why they paint the straight sides of a building with straight lines, even though according to the true art of perspective this is incorrect.... Crack that nut, you artists!"[10] This was endorsed by none other than Kepler, at least insofar as he admitted the possibility that the objectively straight tail of a comet or the objectively straight trajectory of a meteor is subjectively perceived as a curve. What is most interesting is that Kepler fully recognized that he had originally overlooked or even denied these illusory curves only because he had been schooled in linear perspective. He had been led by the rules of painterly perspective to believe that straight is always seen as straight, without stopping to consider that the eye in fact projects not onto a *plana tabella* but onto the inner surface of a sphere.[11] And indeed, if even today only a very few of us have perceived these curvatures, that too is surely in part due to our habituation – further reinforced by looking at photographs – to linear perspectival construction: a construction that is itself comprehensible only for a quite specific, indeed specifically modern, sense of space, or if you will, sense of the world.

Thus in an epoch whose perception was governed by a conception of space expressed by strict linear perspective, the curvatures of our, so to speak, spheroidal optical world had to be rediscovered. However, in a time that was accustomed to seeing perspectivally – but not in linear perspective – these curvatures were simply taken for granted: that is, in antiquity. In antique optics and art theory (as well as in philosophy, although here only in the form of analogies) we constantly encounter the observations that straight lines are seen as curved and curved lines as straight; that columns must be subjected to *entasis* (usually relatively weak, of course, in classical times) in order not to appear bent; that epistyle and stylobate must be built curved in order to avoid the impression of sagging. And, indeed, the familiar





curvatures of the Doric temple attest to the practical consequences of such findings.[12] Antique optics, which brought all these insights to fruition, was thus in its first principles quite antithetical to linear perspective. And if it did understand so clearly the spherical distortions of form, this only follows from (or at least corresponds to) its still more momentous recognition of the distortions of magnitude. For here, too, antique optics fit its theory more snugly to the factual structure of the subjective optical impression than did Renaissance perspective. Because it conceived of the field of vision as a sphere,[13] antique optics maintained, always and without exception, that apparent magnitudes (that is, projections of objects onto that spherical field of vision) are determined not by the distances of the objects from the eye, but rather exclusively by the width of the angles of vision. Thus the relationship between the magnitudes of objects is, strictly speaking, expressible only in degrees of angle or arc, and not in simple measures of length.[14] Indeed Euclid's Eighth Theorem explicitly preempts any opposing view. Euclid states that the apparent difference between two equal magnitudes perceived from unequal distances is determined not by the ratio of these distances, but rather by the far less discrepant ratio of the angles of vision (Figure 4).[15] This is diametrically opposed to the doctrine behind modern perspectival construction, familiar in the formula of Jean Pélerin, known as Viator: "*Les quantitez et les distances Ont concordables différences*" ("The quantities and the distances vary proportionally").[16] And perhaps it is more than mere accident that in Renaissance paraphrases of Euclid, indeed even in translations, precisely this Eighth Theorem was either entirely suppressed or "emended" until it lost its original meaning.[17] Evidently, the contradiction was felt between Euclid's *perspectiva naturalis* or *communis*, which sought simply to formulate mathematically the laws of natural vision (and so linked apparent size to the visual angle),

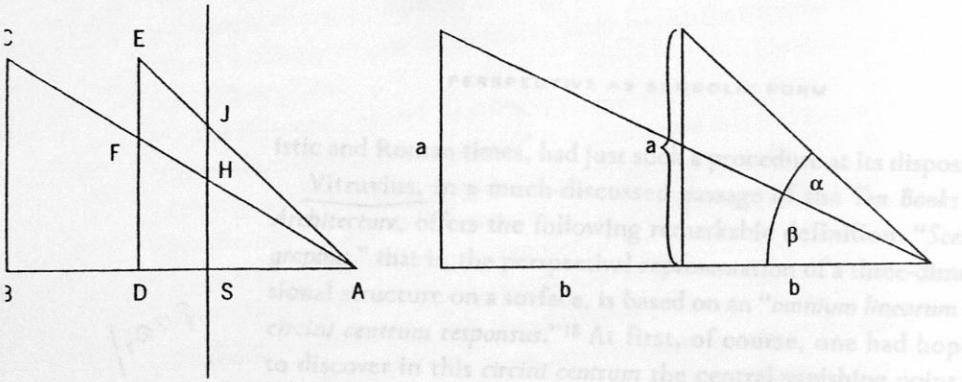



FIGURE 4. Contrast between the "linear perspectival" and "angle-perspectival" constructions: in linear perspective (left), the apparent sizes (*HS* and *JS*) are inversely proportional to the distances (*AB* and *AD*); in angle perspective (right), the apparent sizes ($\beta$ and $\alpha + \beta$) are not inversely proportional to the distances ($2b$ and $b$).

and the *perspectiva artificialis* developed in the meantime, which on the contrary tried to provide a serviceable method for constructing images on two-dimensional surfaces. Clearly, this contradiction could be resolved only by abandoning the angle axiom; to recognize the axiom is to expose the creation of a perspectival image as, strictly speaking, an impossible task, for a sphere obviously cannot be unrolled on a surface.



## II

At this point we are bound to wonder whether and in what way antiquity itself might have developed a geometrical perspective. The ancients, as far as we know, never swerved from the principle that apparent magnitudes were determined not by distances but by angles. On the one hand, it is clear that as long as it respected this principle, antique painting cannot very well have contemplated a projection upon a surface, but rather would have had to adhere to a projection upon a spherical surface. On the other hand, there can be no doubt that antique painting was even less prepared than was the Renaissance to work in practice with "stereographic" projection, for example in Hipparchos's sense. We thus have to consider, at most, whether or not antiquity managed to work out an artistically serviceable approximation. We might imagine such a construction founded on the notion of a "sphere of projection" – or, in plan and elevation, a circle of projection – with, however, the arcs of the circle replaced by their chords. This would achieve a certain approximation of the depicted magnitudes to the widths of the angles, without posing any more technical problems than the modern procedure. And indeed it seems possible – we dare not claim this with any certainty – that antique painting, at least by late Hellen-

istic and Roman times, had just such a procedure at its disposal. Vitruvius, in a much-discussed passage of the *Ten Books on Architecture*, offers the following remarkable definition: "*Scenographia*," that is, the perspectival representation of a three-dimensional structure on a surface, is based on an "*omnium linearum ad circini centrum responsus*."[18] At first, of course, one had hoped to discover in this *circini centrum* the central vanishing point of modern perspective. But not a single surviving antique painting possesses such a unified vanishing point. More importantly, the words themselves appear to rule out this interpretation, for *circini centrum* properly means "compass point," not "center of a circle": the central vanishing point of modern linear perspective, the mere convergence point of orthogonals, cannot possibly be construed as the fixed point of a compass.[19] If, however, Vitruvius is speaking about an exact perspectival construction at all (which the mention of the *circinus* still implies), there is at least a possibility that Vitruvius meant by *centrum* not a vanishing point within the picture, but rather a "center of projection" standing for the eye of the beholder. That center (and this would conform entirely to the antique angle axiom) would then in preparatory drawings be the center of a circle intersecting the visual rays, just as the straight line representing the picture plane intersects the visual rays in modern perspectival construction. In any event, if one now constructs with the help of such a "circle of projection" (whereby, as said before, the arcs of the circle are replaced by the corresponding chords), the result does conform to the surviving monuments in a crucial respect: the extensions of the orthogonals do not merge at a single point, but rather only weakly converge, and thus meet in pairs at several points along a common axis. For when the circle is rolled out, the arcs break apart, so to speak, at the tips. This creates a "fishbone" effect (Figure 5).





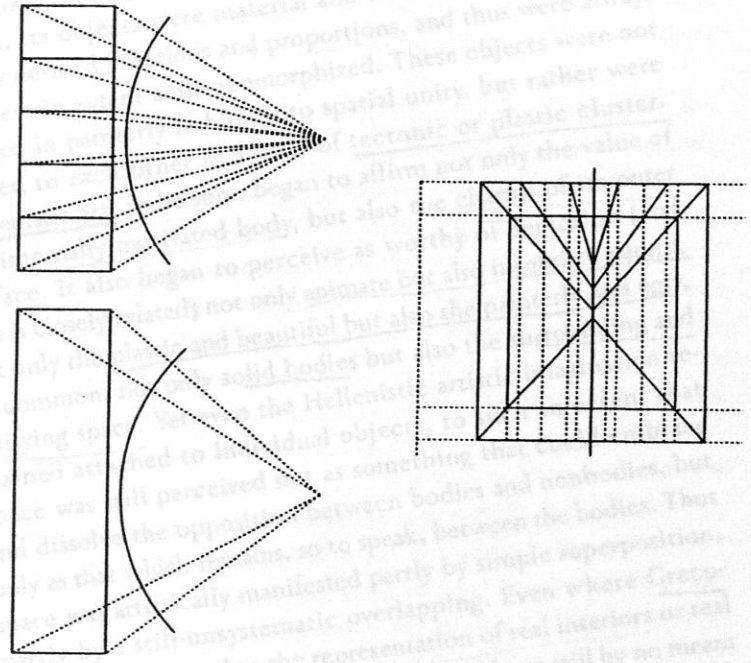


FIGURE 5. Antique "angle-perspectival" construction of a rectangular interior space ("space box"). Left above: plan. Left below: elevation. Right: perspectival image arrived at by combining the segments marked off on the "projection circle."

It is not clear that such an interpretation of the Vitruvius passage can be sustained; it can hardly be proved, since the surviving pictures almost without exception are not rigorously constructed. At any rate, this fishbone or, more formally put, vanishing-axis principle was, at least as far as we can monitor it, crucial in antique spatial representation. Sometimes we find it in the form of a partial convergence, as just described and in accord with our hypothetical circle-construction (Plate 1); sometimes in the

more schematic, but more practicable, form of a more or less pure parallelism of oblique orthogonals. The latter version is attested already on southern Italian vases of the fourth century B.C. (Plates 2 and 3).[20]

But this mode of representing space suffers, in comparison to the modern mode, from a peculiar instability and internal inconsistency. For the modern vanishing-point construction distorts all widths, depths and heights in constant proportion, and thus defines unequivocally the apparent size of any object, the size corresponding to its actual magnitude and its position with respect to the eye. That is precisely the enormous advantage of the modern method, precisely why it was so passionately pursued. A constant distortion is impossible under the vanishing-axis principle because the arrangement of the rays has no validity. This is strikingly illustrated by the inability of the vanishing-axis principle to foreshorten correctly a checkerboard pattern: the squares in the middle are either too large or too small. Already in antiquity, but then above all in the late Middle Ages, when this construction was revived in many parts of Europe, such awkward discrepancies were concealed by an escutcheon, a festoon, a bit of drapery or some other perspectival fig leaf.[21] Moreover, the diagonals of a checkerboard constructed in this way will only run straight if the depth intervals in the rear half of the board appear to grow, instead of diminishing as they should; and conversely if the intervals do diminish, then the diagonals will appear broken.

Granted, this looks more like a mathematical than an artistic matter, for one might with justice point out that the relative imperfection, indeed even the total absence, of a perspectival construction has nothing to do with artistic value (just as, conversely, the strict observance of perspectival laws need in no wise encroach upon artistic "freedom"). But if perspective is not a factor of value, it is surely a factor of style. Indeed, it may even be





characterized as (to extend Ernst Cassirer's felicitous term to the history of art) one of those "symbolic forms" in which "spiritual meaning is attached to a concrete, material sign and intrinsically given to this sign." This is why it is essential to ask of artistic periods and regions not only whether they have perspective, but also which perspective they have.

The art of classical antiquity was a purely corporeal art; it recognized as artistic reality only what was tangible as well as visible. Its objects were material and three-dimensional, with clearly defined functions and proportions, and thus were always to a certain extent anthropomorphized. These objects were not merged in painterly fashion into spatial unity, but rather were affixed to each other in a kind of tectonic or plastic cluster. Hellenistic art, to be sure, began to affirm not only the value of the internally motivated body, but also the charms of its outer surface. It also began to perceive as worthy of depiction (and this is closely related) not only animate but also inanimate nature, not only the plastic and beautiful but also the painterly and ugly, or common, not only solid bodies but also the surrounding and unifying space. Yet even the Hellenistic artistic imagination remained attached to individual objects, to such an extent that space was still perceived not as something that could embrace and dissolve the opposition between bodies and nonbodies, but only as that which remains, so to speak, between the bodies. Thus space was artistically manifested partly by simple superposition, partly by a still-unsystematic overlapping. Even where Greco-Roman art advanced to the representation of real interiors or real landscape, this enriched and expanded world was still by no means a perfectly unified world, a world where bodies and the gaps between them were only differentiations or modifications of a continuum of a higher order. Depth intervals have become palpable, but cannot be expressed in terms of a fixed "module." The

foreshortened orthogonals converge, but they never converge toward a single horizon, not to speak of a single center (even if in representations of architecture, as a rule, the rising of the base lines and the fall of the roof lines are observed).[22] Magnitudes generally diminish as they recede, but this diminution is by no means constant, indeed it is always being interrupted by malproportioned figures, figures "not to scale." The transformations effected by distance and the intervening medium upon the form and color of bodies are represented with such bold virtuosity that the style of these paintings has been held up as a precursor of, or even a parallel to, modern Impressionism; and yet they never achieve unified "lighting."[23] Even when the notion of perspective as "seeing through" is taken seriously – for example, when we are meant to believe that we are looking through a row of columns onto a continuous landscape (see Plate 4) – the represented space remains an aggregate space; it never becomes that which modernity demands and realizes, a systematic space.[24] Precisely here it becomes clear that antique "impressionism" was only a quasi impressionism. For the modern movement to which we give that name always presupposes that higher unity, over and above empty space and bodies; as a result its observations automatically acquire direction and unity. This is how Impressionism can so persistently devalue and dissolve solid forms without ever jeopardizing the stability of the space and the solidity of the individual objects; on the contrary, it conceals that stability and solidity. Antiquity, on the other hand, lacking that domineering unity, must, so to speak, purchase every spatial gain with a loss of corporeality, so that space really seems to consume objects. This explains the almost paradoxical phenomenon that so long as antique art makes no attempt to represent the space between bodies, its world seems more solid and harmonious than the world represented by modern art; but as soon as space is





included in the representation, above all in landscape painting, that world becomes curiously unreal and inconsistent, like a dream or a mirage.[25]

Antique perspective is thus the expression of a specific and fundamentally unmodern view of space (although it is certainly a genuinely *spatial* view, Spengler notwithstanding). Antique perspective is furthermore the expression of an equally specific and equally unmodern conception of the world. And only now can we understand how the antique world was able to satisfy itself with what Goethe called "such a precarious, even false" rendition of the impression of space.[26] Why did the ancients fail to take the apparently small step of intersecting the visual pyramid with a plane and thus proceed to a truly exact and systematic construction of space? To be sure, that could not happen as long as the angle axiom of the theoreticians prevailed. But why did they not simply disregard the axiom, as would happen a millennium and a half later? They did not do it because that feeling for space which was seeking expression in the plastic arts simply did not demand a systematic space. Systematic space was as unthinkable for antique philosophers as it was unimaginable for antique artists. Thus it would be methodologically quite unsound to equate the question "Did antiquity have perspective?" with the question "Did antiquity have *our* perspective?" as was done in the days of Perrault and Sallier, Lessing and Klotzen.

As various as antique theories of space were, none of them succeeded in defining space as a system of simple relationships between height, width and depth.[27] In that case, in the guise of a "coordinate system," the difference between "front" and "back," "here" and "there," "body" and "nonbody" would have resolved into the higher and more abstract concept of three-dimensional extension, or even, as Arnold Geulincx puts it, the concept of a "*corpus generaliter sumptum*" ("body taken in a gen-

eral sense"). Rather, the totality of the world always remained something radically discontinuous. Democritus, for example, constructed a purely corporeal world out of indivisible elements, and then, only in order to secure for those elements the possibility of movement, postulated further the infinite void as a *mē on* or nonbeing (even if, as a correlate to the *on* or being, this is something of a necessity). Plato let space stand in opposition to the world of elements reducible to geometrically formed bodies, as their formless *huperdochē* or receptacle (indeed it is even hostile to form). Aristotle, finally, with a basically quite unmathematical transfer of qualitative categories to the realm of the quantitative, attributed six dimensions (*diastaseis*, *diastēmata*) to *topos koinos* or general space (up and down, front and back, right and left), even though individual bodies were sufficiently defined by three dimensions (height, width, depth). Moreover, Aristotle conceived this "general space" in turn as merely the furthest frontier of an absolutely large body, namely the outermost celestial sphere – just as the specific location of individual things (*topos idios*) is for him the frontier where the One meets the Other.[28] Perhaps this Aristotelian doctrine of space illustrates with special clarity the inability of antique thought to bring the concrete empirical "attributes" of space, and in particular the distinction between "body" and "nonbody," to a common denominator of a *substance étendue*: bodies are not absorbed into a homogeneous and infinite system of dimensional relationships, but rather are the juxtaposed contents of a finite vessel. For, just as for Aristotle there is no "quantum continuum" in which the quiddity of individual things would be dissolved, so there is for him also no *energeiai apeiron* (actual infinite) which would extend beyond the *Dasein* of individual objects (for, in modern terms, even the sphere of fixed stars would be an "individual object").[29] And precisely here it becomes quite clear





that "aesthetic space" and "theoretical space" recast perceptual space in the guise of one and the same sensation: in one case that sensation is visually symbolized, in the other it appears in logical form.