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SYMBOLIC MEANING IN LEONARDO'S AND RAPHAEL'S PAINTED ARCHITECTURE

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Perspective is the curb and guide of painting.

Leonardo, *Treatise on Painting*

THIS study of Leonardo's *Cenacolo* and Raphael's *Disputa* and *School of Athens*, together with one on Titian's *Pesaro Altarpiece* to be published elsewhere, form a sequel to my earlier work on the architecture in some paintings by Domenico Veneziano and Piero della Francesca: I wanted to see how the greatest High Renaissance painters dealt with the problems and opportunities of painted architecture, and particularly whether their work continued what I had called a tradition of symbolic architecture.¹ One especially interesting aspect of these later paintings, in contrast to the earlier ones, was that, being still in their original positions, they would make it possible to reconstruct more fully the intentions of the artist and the experience of the viewer.

Since this is not a very well known area of inquiry, I will begin with a few general observations. First, this kind of study, as I conceive it, rests on the following chain of reasoning. There is good cause to believe that many post-Brunelleschan painters of architecture first designed a floor plan and elevation and then, choosing an appropriate viewing distance and eye level, translated these to the flat surface of their paintings.² These plans and elevations, if we could see them, would be interesting and perhaps valuable evidence of the artist's thought. Since the historical enterprise consists largely in rediscovering and reenacting the thought of historical figures, the historian concerned with this kind of painting ought to retrieve these plans and elevations if he can.

In the light of this reasoning, I would like to make two comments on present scholarly practice. The first is that most of what has been written about the use of space in fifteenth-century Italian painting takes little or no account of the precise shape and size of that space—in John White's *Birth and Rebirth of Pictorial Space*, for instance, one looks in vain for even a single floor plan of painted

architecture.³ If the principles stated above are correct, then this reluctance to come to grips with the concrete problems of painted architectural space is a mistake.

My second comment pertains to the reconstructions of painted architecture that have been made by a few other scholars. Almost all these reconstructions are partly inconsistent with the premises just mentioned because, although they do retrieve a floor plan of the painting, they cannot succeed in retrieving the *painter's* plan since they do not correctly define it—or perhaps it would be fairer to say that they do not retrieve it since they do not set out to find it. We must remember that a floor plan consists of lines and numbers, a number representing the length of a line in a given unit of measure; the painter's floor plan must have shown lengths in the unit of measure that he chose to use. But most modern reconstructions determine lengths in metric or Anglo-American units of measure, which obviously cannot have been the unit used by a fifteenth-century Italian artist.⁴ Therefore the modern reconstructions, although they may show us the correct shape of the painter's floor plan, cannot tell us the numbers that he used to indicate its dimensions.

Now this insistence on seeking the painter's unit of measure, and therefore the numbers on his floor plan, is not, I hope, mere pedantry. In searching for a painting's meaning and purpose, for the thought of the painter and perhaps of his patron or an adviser, we make inferences from every available datum—from the style and composition, from the persons, actions, objects and places painted, from other works of the painter and of other artists, from literary and other written sources, from the biographies of the painter and his patron, and from the historical situation at the time. We never know beforehand which data will prove the more enlightening and which the less. Obviously, numbers, too, can support inference. Modern perspective studies, in failing to search for the *painter's* unit of measure and *his* dimensions, may therefore be missing a crucial clue to the understanding of the work and its maker.

The reader should remember that the following argument, like all exegetical thought, is hypothetical. It starts from two assumptions, the shape of a floor or ceiling quadrilateral and the painter's unit of measure; works out the resulting floor plan; tests the plan, and thereby the assumptions on which it is based, by tests intrinsic and extrinsic (I have limited probative discussion to the notes); and concludes by considering elements of the painter's thought suggested by his design of the architecture.⁵ If this interpretation wins adherents and withstands attack by explaining aspects of the painting that would otherwise per-

plex, and by fitting into a consistent and likely account of the painter's thought, then the chances are good that it is correct.

LEONARDO'S AND HIS PREDECESSORS' ARCHITECTURAL SETTINGS OF THE CENACOLO

Much has been made of the difficulty of deciphering the perspective scheme in Leonardo's *Cenacolo* (Fig. 1), and one scholar has even gone so far as to maintain that we should not try: it would be "neither pious nor scientific." But the same scholar called the painting "the most completely excogitated picture in the history of art"; and surely such completeness included the rather elementary excogitation of choosing a depth, width and height for the room and a viewing distance (which of course had to be decided on before the room could be translated to the painting). If this is so, then it is both the duty and opportunity of the historian to try to discover them instead of succumbing to inhibitions which would surely not have hindered an artist so mathematically and geometrically inclined as Leonardo.⁶

Thanks to the coffered ceiling, the task is not really so very difficult. Let us continue the ceiling to its intersection with the picture plane; assume that the coffers are square (seen foreshortened there is no way of knowing), and that Leonardo used the same system of measurement as was used in the cities where he was born and worked, that is, a unit about one-third the height of a man, called a *braccio*; compare the coffer squares with the figures below; and estimate the size of a square as 2 by 2 *braccia* in the scale of the painting (Fig. 2).⁷ Doing this, we find the hall to be 28 *braccia* deep by 12 wide by 9 high, the "correct" viewer to be standing 12 *braccia* from the painting, and the sum of painted and real space (converting the metric dimensions of the refectory to *braccia* of the painting) to be 72 by 11, and then 12, *braccia* (Fig. 3).⁸

Assuming that we now know the floor plan and viewing distance which Leonardo chose for the scene, two subjects of speculation present themselves: what can we learn about the painting by comparing Leonardo's solution of the architectural problem with the solutions chosen by his predecessors? and what, beyond this general relation of the painting to the traditional treatment of the scene, were the particular merits of Leonardo's solution for this subject and site? I will treat these two questions in that order.

Let us first survey the problems that a painter faced in painting a *Cenacolo* on the end wall of a refectory and then examine the solutions devised by Leonardo's immediate predecessors. Scenes of eating were naturally a favorite



Fig. 1. LEONARDO DA VINCI, *Cenacolo*. S. Maria delle Grazie, Milan

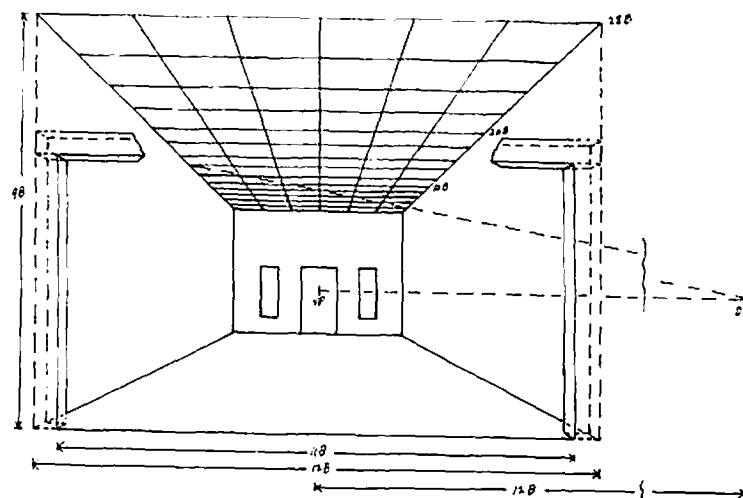


Fig. 2. Diagram of the horizon, floor, walls and ceiling of Fig. 1

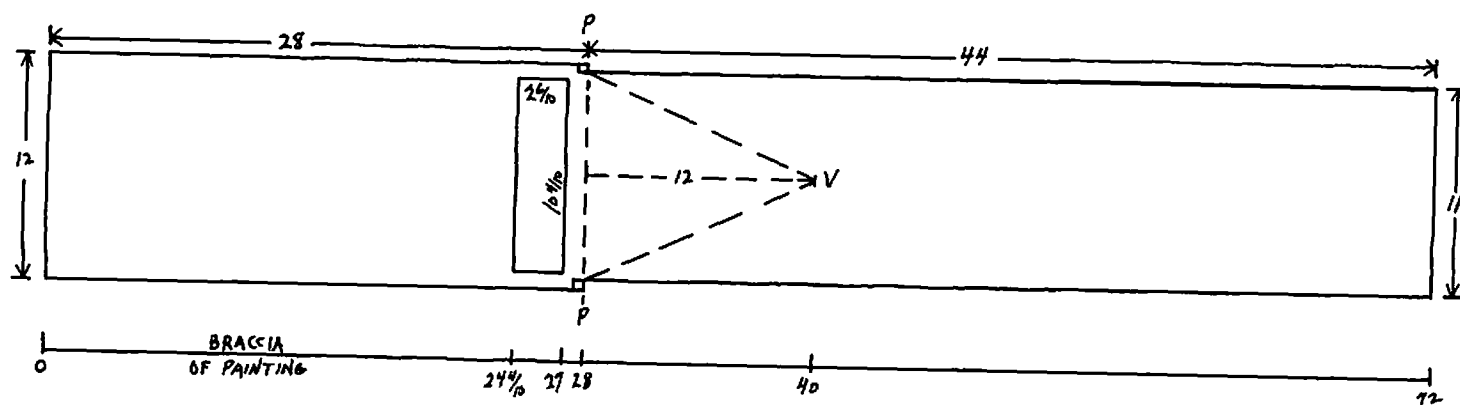


Fig. 3. Floor plan of Figs. 1 and 5

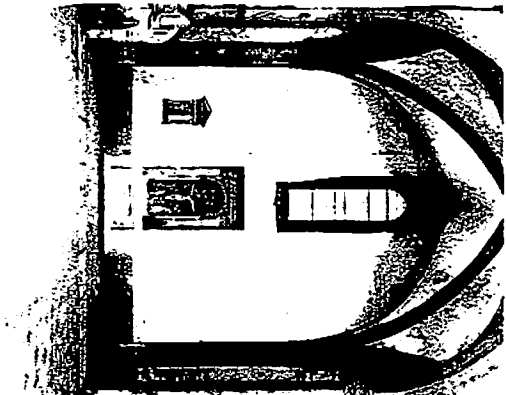


Fig. 4. MASACCIO, *Trinity*, S. Maria Novella, Florence



Fig. 5. Refectory, S. Maria delle Grazie, Milan

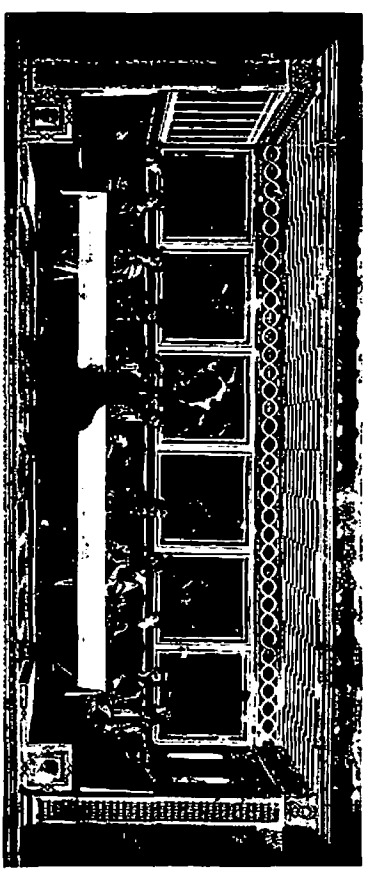


Fig. 6. ANDREA DA CASTAGNO, *Cenacolo*, S. Apollonia, Florence

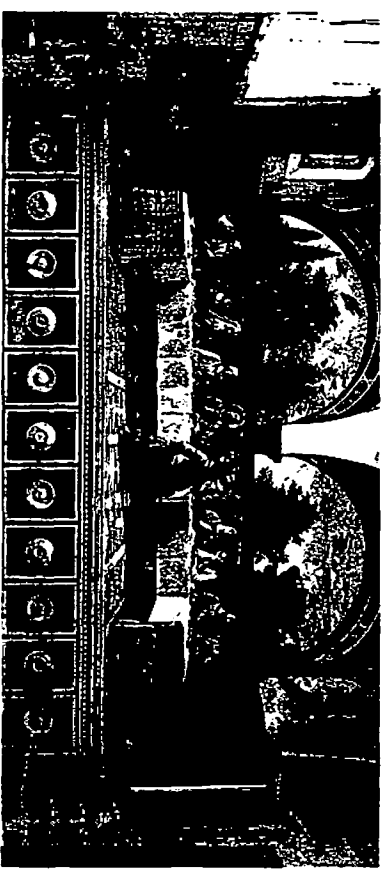


Fig. 7. DOMENICO GHIRLANDAIO, *Cenacolo*, Ognissanti, Florence

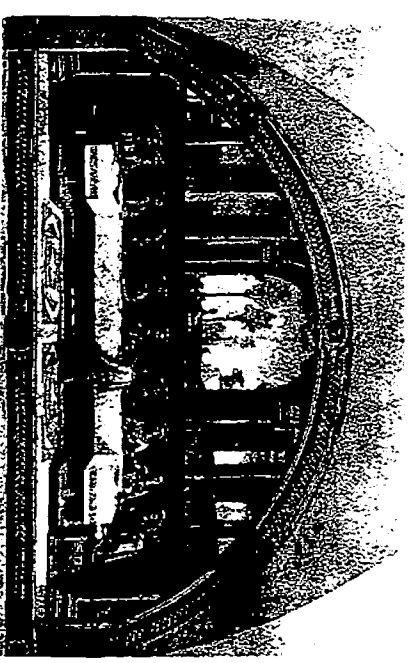


Fig. 8. PERUGINO, *Cenacolo*, S. Onofrio, Florence

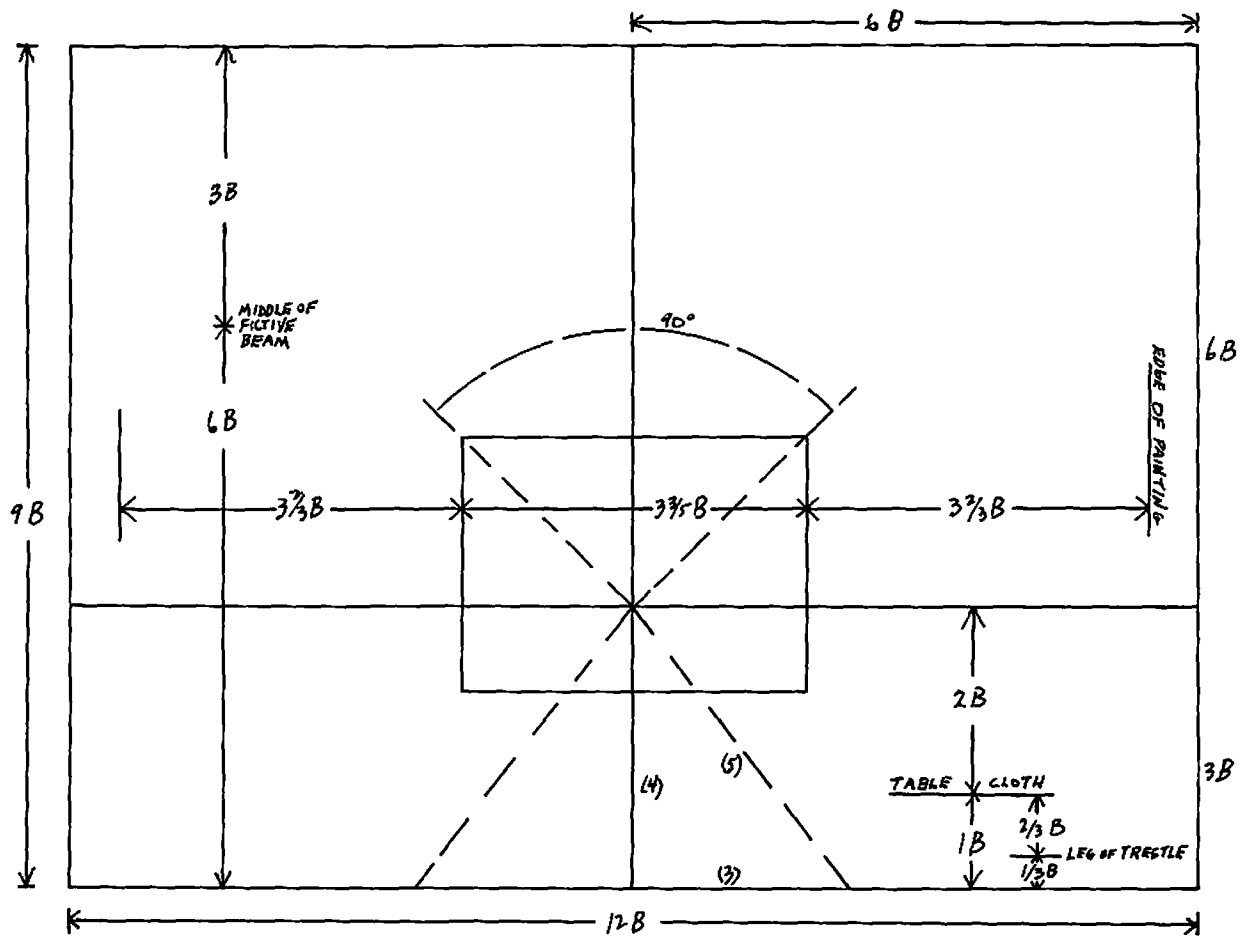


Fig. 9. Principal two-dimensional proportions of Fig. 1

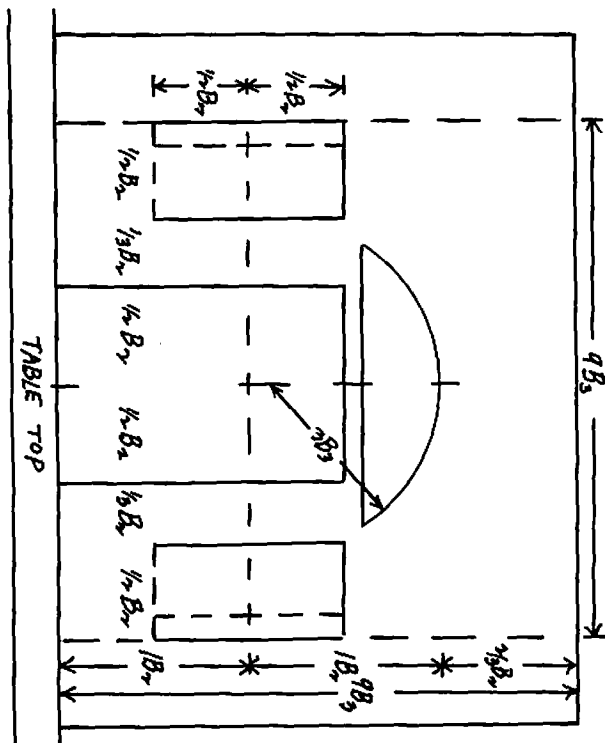


Fig. 11. Composition of the cable and far wall in Fig. 1

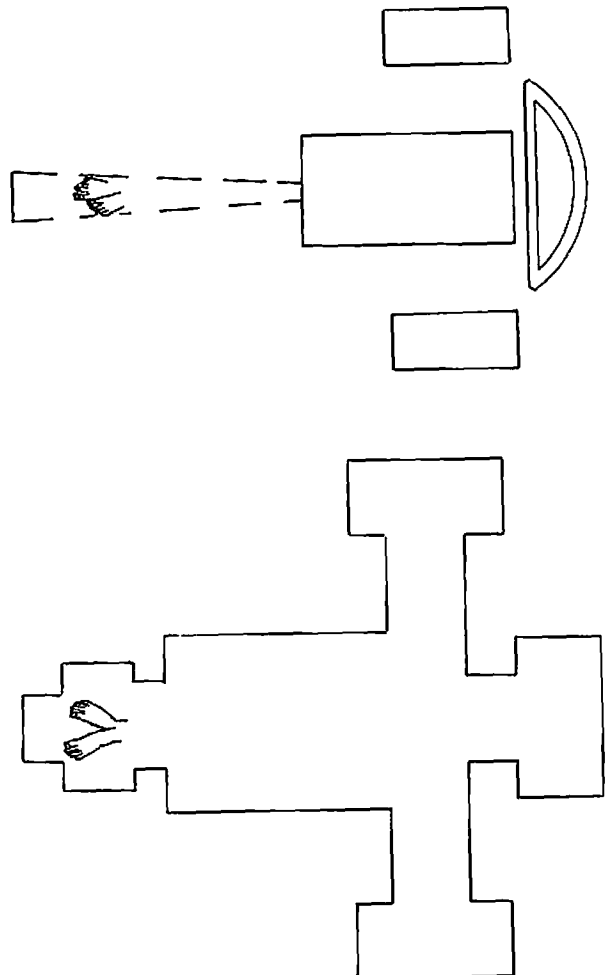


Fig. 10. Left: center floor stripe, door, windows and pediment of Fig. 1
Right: shape of a twelfth-century crucifix



Fig. 12. RAPHAEL, *School of Athens*. Vatican City



Fig. 13. Pythagoras group, detail of Fig. 12



Fig. 14. Euclid (?) group, detail of Fig. 12

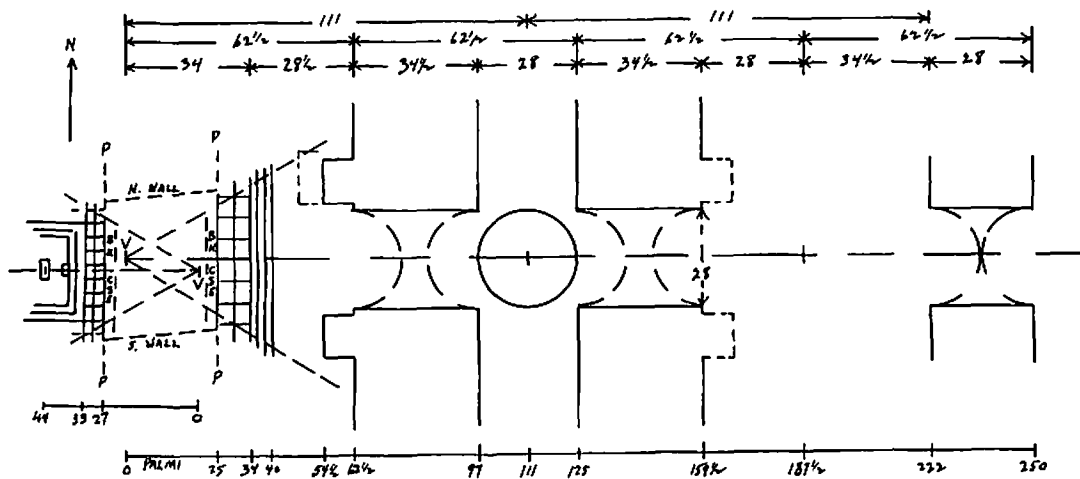


Fig. 15. Floor plan of Fig. 12

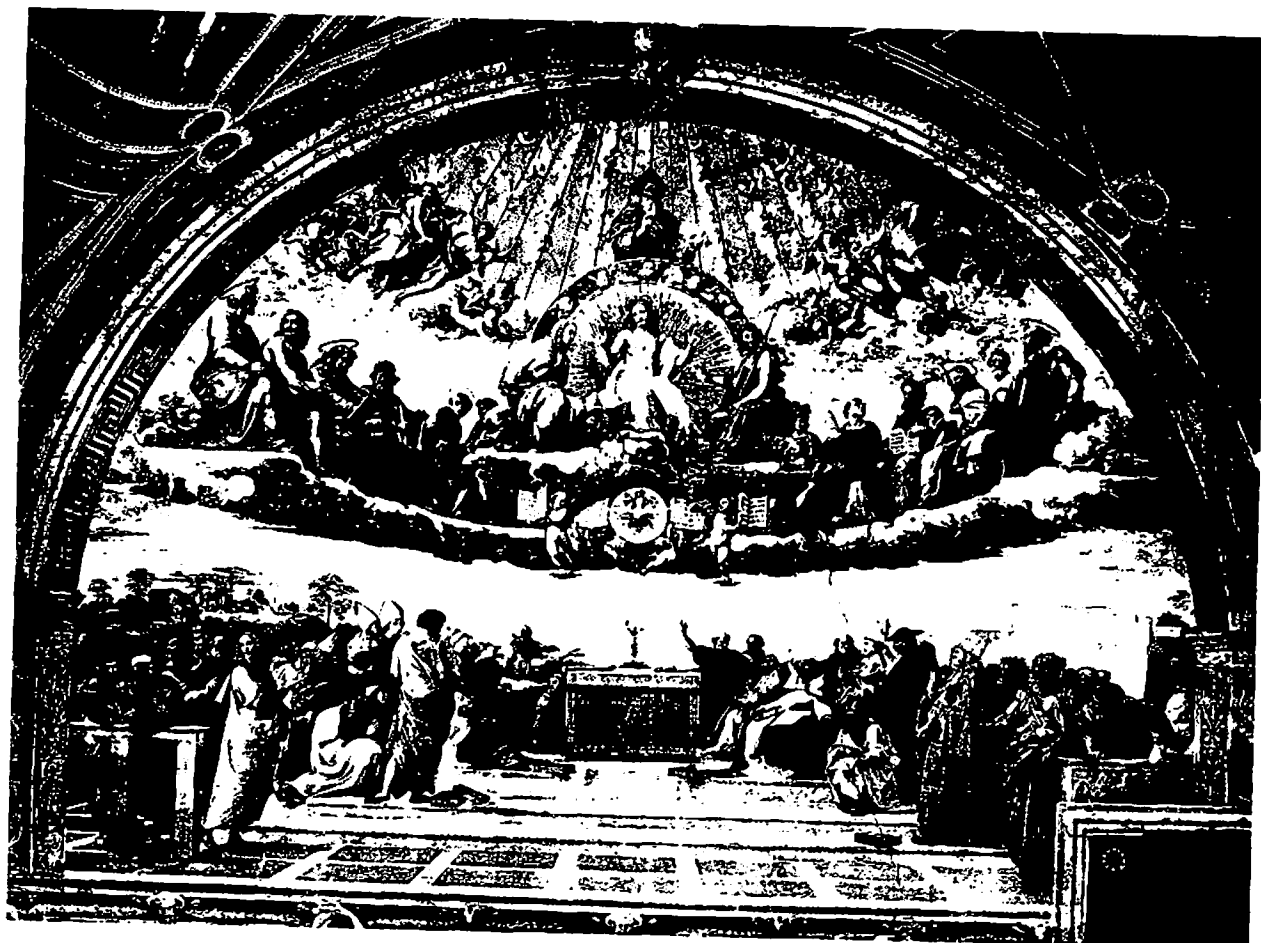
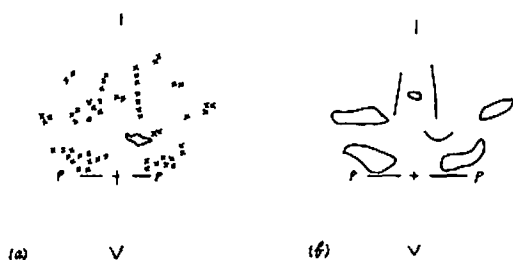


Fig. 16. RAPHAEL, *Disputa*. Vatican City



PYTHAGORAS'S TETRACTYS	DISPUTA
I	GOD 1
I I	CHRIST 22
I I I	PROPHETS & SAINTS 33
I I I I	HOST TO VIEWER 44
X	FLOOR

Fig. 17. Pythagoras's tetractys and the dimensions of Fig. 16

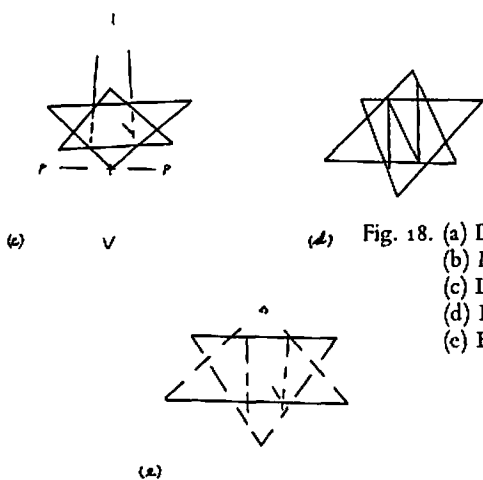


Fig. 18. (a) Disposition of figures in Fig. 12
(b) Major groups of figures in (a)
(c) Linear abstraction of (b)
(d) Euclid's (?) design
(e) Euclidean design of figures in Fig. 16

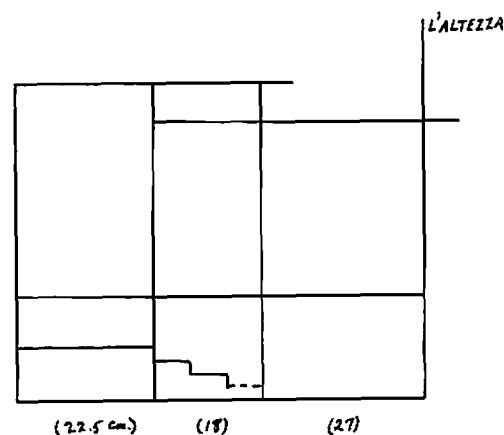


Fig. 19. RAPHAEL, scale drawing of section through front of Fig. 12. Biblioteca Ambrosiana, Milan

subject for this position: of the five scenes bordering the central crucifixion which Taddeo Gaddi painted about 1335 on the west wall of the refectory of S. Croce, no less than four show diners at table, the *Cenacolo* occupying the whole of the lowest register. At least six versions of the *Cenacolo* painted before Leonardo's survive on the end walls of Florentine refectories.⁹ But if for the prior the subject was ideal, for the painter following Brunelleschi the site was far from being so. The viewer would naturally think of the painted scene as an extension of the real scene of monks assembled for a meal: both painted and real figures eat and drink, use similar, if not identical, table settings, sit at tables similar in appearance and perhaps symmetrical in position. It would be a natural expectation, then, that the space depicted in the painting should prolong the real space of the refectory.¹⁰ The oblong shape of a refectory, however, makes a convincing pictorial extension of its space almost impossible for three reasons, which correspond to the viewer's location in three dimensions.

Perhaps worst of all, a refectory greatly aggravates the contradiction between the single, fixed viewing station required by Brunelleschian perspective and the reality of viewers who are free to move in depth. A viewer naturally stands at least a width away from a painting in order to take in its full width comfortably and without rotating his head; and chapels, being usually not far from square, prevent or discourage viewing from a much greater distance. But a refectory! It is generally between three and four times as long as it is wide, and the viewer can vary his station over a range two or three times the width of the painting.¹¹ If this is an interior scene, like the *Cenacolo*, and the viewer moves very far forward or backward from the "correct" station, the relation of foreground and background objects, which is reasonable for that station, may become incongruous: particularly, the angle between the foreshortened floor, side walls or ceiling, and the end wall in the painting may sensibly diverge from the normal ninety degrees which a viewer infers when standing at the "correct" station. A good example of this effect is the aspect of the ceiling in that milestone of perspective painting, Masaccio's *Trinity*, seen from a distance of about a small refectory's length, or some three times the prescribed viewing distance (Fig. 4): the ceiling seems to slope down at a steep angle from the horizontal.

The second problem posed by a refectory arises from the viewer's freedom to move laterally. One might think that at least the narrowness of the room would give the painter an advantage, since it prevents the viewer from straying far from the axis through the center of the painting, somewhere along

which his ideal station is customarily placed; and this would indeed be true, if he could be restrained by invisible walls. But the long side walls of a refectory have a most unfortunate effect on walls running into depth in the painting: as the viewer moves toward a side wall of the refectory and the apparent width of that wall consequently diminishes, a similar wall on the same side of the painting, perhaps even a wall ostensibly extending the real wall, behaves in a distressingly opposite way, swelling instead of shrinking. It seems to swell (I suppose) because the viewer moves slightly nearer to it and farther from its counterpart on the opposite side of the painting, because he sees it full-face but the opposite wall slightly foreshortened, and because of its contrast with the shrinking real wall. Where a painted side wall takes up much of the width of a painting or joins the real wall, this incongruous effect can be fatal to any illusion of a viewer very distant from the painting and not on the center axis, that the painted space continues the real space.

Lastly, a problem arises on account of the viewer's vertical location, the one dimension in which he is ordinarily not free to move. By Leonardo's time the general problem of the relation of the horizon in a painting to the height of a viewer's eye above the floor had been resolved, at least in practice: experience had shown that for narrative paintings above the viewer's eye a "correct" horizon at his eye level, and therefore usually below the floor in the painting, was not satisfactory, and viewers were well accustomed to suspending their sense of horizontality enough to allow their being persuaded that they were looking horizontally when in fact they were looking up.¹² For a viewer at the far end of a long refectory this suspension is even easier, since the angle by which his line of sight rises above horizontal is correspondingly smaller. But at the same time, and precisely because of this greater distance from the painting, the difference between his eye level and the horizon of the painting results in a serious threat to his illusion: his field of view now takes in the side walls of the building and their orthogonals, which aim down at his personal vanishing point, and he sees them harshly interrupted at the juncture of the side wall and the painting, where the orthogonals of the latter suddenly bend up to aim at its higher vanishing point (Fig. 5).

In the half-century before Leonardo's painting (1495-98), his predecessors had evolved a strategy for protecting the viewer's illusion of continuity as much as possible against these threats posed by the shape of a refectory. Andrea da Castagno (1447), Domenico Ghirlandaio (Ognissanti, 1480) and Perugino (1490) all simply forestalled the possibility of incongruity between near

and more distant objects by screening out the space beyond the diners—Andrea all of it, Domenico and Perugino enough to prevent the juxtaposition of the figures with anything more distant (Figs. 6, 7 and 8). All three limited their side walls to a small proportion of the width of the painting, and Perugino even went so far as to avoid any appearance of foreshortening at the top by locating the horizon virtually at that level.¹³ True, he did venture some timid architecture in the background, but the very fact that it consists only of columns is one more testimony to his and his predecessors' horror of foreshortened walls. Both he and Andrea took the additional precaution of keeping the side walls in their paintings well away from those of the refectory, thus making the walls' opposite behavior for the lateral viewer less conspicuous and avoiding any obvious break between the orthogonals of building and painting.¹⁴

In the matter of the viewing distance each painter chose a different solution, and each solution had some merit as a defense of illusion. Andrea chose a distance so great—four-fifths the length of the refectory—that a viewer could not appreciably exceed it.¹⁵ Ghirlandaio, instead, chose two-fifths of the refectory's length, thus reducing the average deviation nearly to a minimum.¹⁶ Perugino went to the opposite extreme from Andrea and put his "correct" viewer so close to the painting—one width away—that he would no longer see the foreshortened side walls of the refectory at all.¹⁷ For this viewer there would be little if any incongruity between real and painted space, since the few meters of real space left could easily seem but the extension of the painted space. In the case of the more distant viewer, for whom the refectory's side walls would increasingly define the real space, Perugino's concealment and avoidance of foreshortening in the painting would mitigate any contradiction between its space and that of the refectory.

The components of this defensive strategy developed by Leonardo's immediate predecessors constitute, almost without exception, a list of the things which Leonardo did *not* do.¹⁸ Choosing, as had Perugino, nearly the shortest possible viewing distance, 12/11 of the painting's width, he showed no such concern as Perugino's for the visual comfort of the distant viewer. Far from screening out distant objects, he posed his figures at the near end of a long hall and opened a door and windows in the far wall. Instead of avoiding incongruity between the figures and these distant objects, he positively invited it by framing Christ's and Thomas's heads in the door and a window: the viewer at the far end of the refectory who senses how much farther he is from Christ than Christ is from the wall beyond, will read the width of Christ's head and

hair as roughly one-third the width of the door, in our scale some 2 feet, and the length of Thomas's head as about $2\frac{1}{2}$.¹⁹ Instead of mitigating the inevitable distortion of the side walls for the distant viewer by restricting their width and separating them from the walls of the refectory, Leonardo stretched both of them across one-third of the painting and carried them virtually to a junction with the real walls. Consequently, the distant viewer gets the strong impression that they meet the rear wall at an angle of one hundred twenty degrees or more and that, seen from a lateral position, they contradict the appearance of the real walls (Fig. 5).²⁰ To the still greater disturbance of the distant viewer, Leonardo carried the conspicuous lateral orthogonals defined by the tops of the tapestries almost to a junction with the refectory walls at a point where their inconsistency with the orthogonals formed by the frieze decorations of the refectory would be most apparent (Fig. 5).²¹ And in addition to all this he violated an elementary principle of illusion, which his predecessors had been careful to observe, by making his figures about twice life size: if Christ were to rise and advance to the picture plane, He would stand some 3.6 meters, or 12 feet, tall.²²

Why so uncompromising a rejection of the defensive strategy formulated by his predecessors, we ask—of the safeguards which they had developed against the threats to illusion posed by the extreme mobility of viewers in a refectory? The answer, I think, is that their defensive way required above all things shallow architectural space, whereas one has only to look at Leonardo's earlier paintings, the *Annunciation* and *Adoration*, at his writings, and at the works of Domenico Veneziano and Piero della Francesca—his true predecessors in the use of architectural space—to see that what interests him is deep space.²³

Domenico and Piero, however, did not have to contend with refectories, as far as we know; how were the special demands of these to be reconciled with the deep architectural space which Leonardo preferred? The answer was simple and bold: he would combine deep space with a short viewing distance and thus exploit all the visual discomfort of the distant viewer, which his predecessors had worked so hard to alleviate, as a magnet to pull him closer to the painting. What the distant viewer sees is troubling, is out of joint; then let him follow the straight and narrow axis of the painting to the proper viewing distance, to the point where there can no longer be any disappointed expectation that the space of Christ should continue the space of the refectory, because there is hardly any refectory left to see. Let him look up at Christ and the disciples in all their double-life-sized majesty—and at nothing else.

One wonders also whether there may not have been in this exhortation to the distant viewer an admonition *ad hominem*. Goethe tells us (and we could reach the same conclusion from archaeological evidence as well) that the prior's table was at the far end of the refectory from the painting—the prior had one of the worst seats in the house.²⁴ Was Leonardo's message preeminently for him and perhaps for the illustrious guests he must have entertained from time to time? Were they to take their meals where their eyes could find no peace and relieve their discomfort only by coming among the lowliest of the monks?²⁵

By some such reasoning Leonardo was emboldened to design a hall for the scene even wider than the refectory instead of narrower, and over twice as deep as it was wide, a hall which came close to adding a second refectory to the first (Fig. 3). Instead of struggling against the long architectural view and trying to wall it in as closely as possible beyond the picture plane, as his predecessors had done, he sympathized with it and generously extended the architecture from a length four times its width to six. The painting was a revolutionary break with the long tradition of shallow, closed space on the end wall of a refectory.

Now let us look for the reasons which may have recommended to Leonardo the particular dimensions that he chose for his deep space. The basic dimensions which confronted him as he attacked the problem were the width and length of the refectory: it is fifteen Milanese *braccia* wide by sixty long.²⁶ As it happens, fifteen is a number that seems quite irrelevant both to Christianity and to the Last Supper; one is hardly surprised that, working in a strong tradition of numerical symbolism, Leonardo decided to impose different dimensions on his space by devising a different scale. The scale which he chose made his painted hall twelve *braccia* wide, and this is, of course, a most appropriate number for the feast of the twelve disciples. On this scale the length of the refectory becomes 44 *braccia*; a great virtue of 28 *braccia* as the length of the painted hall thus appears to be that it results in a total length of real and painted space which is a multiple of twelve. If we consider along with these dimensions, that the viewing distance is twelve *braccia*, we can suspect that Leonardo designed his floor plan and viewer's station with an eye to their permeation by the number of Christ's disciples.²⁷

But the design of architecture and the design of a painting are two different, though related, matters: the painting is, after all, a flat, vertical surface, and on it the elements of the architecture will be seen not as in a floor plan and elevation but as they would form a two-dimensional design traced on a win-

dow. The painter has to design his architecture not only for itself but also for the two-dimensional appearance it will have when the images of objects at different distances are all intercepted by this one fixed plane. Incorporating deeper and shallower forms in one surface design, the painter unifies his work, attains the compositional interest that is the particular domain of painting, and maintains the authority of the surface over the recession of deep space.²⁸

In this blending of the flat and the deep Leonardo especially exercised his geometric and symbolic talents. The whole scene he restrained in a two-dimensional composition of rectangles with proportions of 4:3, 3:2, 2:1, 1:1, and 1:4 (12 by 9, 9 by 6, 6 by 3 and 12 by 6, 6 by 6, and 3 by 12 *braccia*; Fig. 9).²⁹ As if balancing the two sides of the composition on a Christian-Pythagorean fulcrum, he defined with Christ's arms a wedge consisting of two right triangles with sides in the ratio of 3:4:5 (Fig. 9). The deepest element in the painting (except for the landscape), the far wall, he conjoined to the surface in various ways. For one thing, when Christ's feet were still visible against a center floor stripe, the intimation of a monumental twelfth- or thirteenth-century crucifix awaiting Him must have been strong indeed (Fig. 10).³⁰ Another link between the far wall and the foreground is that the upper edge of the table virtually coincides with the (invisible) bottom of the wall. Finally, the design of the wall itself is an intricate concatenation of dimensions in *braccia* of the picture plane (B_1 , Fig. 11) and *braccia* at the depth of the wall (B_2).

One detail of this design particularly shows the stamp of Leonardo's thought: the top of the pediment which finishes the frame around Christ's upper body and is the only curved architectural line in the painting. Leonardo placed the intersection of this arc with the center axis at one picture-plane *braccio* above the vanishing point, but drew the arc with a radius equal to three *braccia* at the depth of the far wall. As a result, the pediment not only epitomizes that mysterious union of three dimensions with two which, for Leonardo, was painting, but symbolizes the far more mysterious union of three and one which is Christianity.³¹

THE PYTHAGOREAN AND EUCLIDEAN STRUCTURE OF RAPHAEL'S "DISPUTA" AND "SCHOOL"

The *School of Athens* (Fig. 12) is an apotheosis of thought: in groups around the two masters of ancient thought (Plato, on the left, and Aristotle) the figures write, read, expound, calculate, or follow intently the thinking of the seers. On either side in the foreground the inquiry is conspicuously mathematical

and geometrical. Pythagoras, his table of numbers and musical ratios held before him for ready reference, writes in a space ruled off from the text for arithmetical or geometrical illustration (Fig. 13). At the right Euclid (or perhaps Archimedes) measures with a divider on a six-pointed design (Fig. 14). It is a foreground to set a viewer measuring and calculating, too; what are the shape and proportions and dimensions of this noble space and what, to follow the example of Pythagoras, their meaning?

The painting being in Rome, the most likely unit of measure is the standard Roman unit (in the Cinquecento) of the *palmi*, a choice perhaps further recommended by the prominence of that part of the body in the two central figures and by the location of the vanishing point close to Plato's left hand. Since the standing figures in the foreground are considerably taller than the width of one floor rectangle (defined by imaginary lines bisecting the continuous white stripes), it seems reasonable to assume for these rectangles a width of three-fourths the height of a standard man, or six *palmi*.³² On the supposition that the depth of a floor rectangle is $4\frac{1}{2}$ *palmi*, the viewing distance proves to be 25 *palmi* (in the scale of the painting), or 6.75 meters, about what one would expect where the maximum viewing distance was probably no more than 7.65 meters (the room is 8.40 meters wide and originally seems to have had bookcases along the east and west walls).³³ The viewing distance conjectured in this way, it is easy to follow the floor plan back (Fig. 15): from the viewer to the bottom of the steps is 34 *palmi* (25 plus 9), to the top of the steps (assuming treads 2 *palmi* deep) 40, and to the front of the pylons $54\frac{1}{2}$ (calculated from the convergence of orthogonals on the upper floor); and from there to the far end of the farther barrel vault all distances can be calculated from the diminishing apparent width of the interval between the pylons and then of the vaults. The painting provides no data for finding the distance to the triumphal arch, but by the time we have extended the plan to the far end of the vaulted aisle, the modular scheme has become sufficiently clear to allow extrapolation of a likely distance of 222 *palmi* to the near, and 250 to the far, side of the arch.³⁴

The modular scheme is elegant mathematics: the module of $62\frac{1}{2}$ *palmi* is the sum of two key dimensions, the length of a vault and the width of the crossing (or the length and width of a vault); it places the center of the crossing at the triply unitary distance of 111 *palmi* from the viewer; it results in the proportion 1:2:4 for the distances from him to the near side of the near vault, the near side of the farther vault, and the far side of the arch; and it makes the distance from him to the far side of the arch ten times the viewing distance. If we mark off

the third module on the plan, as a painter-architect would surely do either on the drawing board or in his mind, we can recognize a correspondence of the ratios 1:2(:3):4 and 1:10 with Pythagoras's *tetractys* ($1+2+3+4=10$; Fig. 13).³⁵

On the wall opposite the *School* Raphael painted the so-called *Disputa* (Fig. 16).³⁶ It, too, is an architectural painting at the bottom—the floor, steps and platform provide a stage for the figures similar to that in the *School*—and what we might call the dimensions of the upper part are very much in tune with those of the *School*: the viewer stands 44 *palmi* from the host on the altar; the prophets and saints sit in a celestial semicircle about 21 *palmi* in inner diameter and therefore (taking $22/7$ as the value of π) 33 *palmi* in circumference; Christ occupies a disc 22 *palmi* in circumference; the structure culminates in the one God.³⁷ Once again the dimensions seem a variation on Pythagoras's *tetractys* (Figs. 13 and 17; the ten numbered rectangles are those of which no part is occupied or overlapped). As if to confirm this relation, Moses sits opposite Pythagoras and holds tablets that are the same shape as the Pythagorean diagram of the musical ratios and that contain the Ten Commandments.³⁸

The underlying structure of the architecture in both paintings, then, seems to be essentially Pythagorean, and Pythagoras clearly deserves his place as the foremost sage in the *School*.³⁹ Instructed by his significance, we might expect a special importance to attach also to Euclid or Archimedes, his almost equally prominent counterpart on the right, and to the six-pointed shape which is the counterpart of his numbers and ratios (Fig. 14).⁴⁰ If on the floor plan of the *School* we plot the positions of the figures (Fig. 18a), they can be seen to divide into the two ranks beside Plato and Aristotle, the three figures on the steps, and five other groups (Fig. 18b; I have omitted four minor pairs of figures and the seated Michelangelo, who was not in the original composition).⁴¹ When the five other groups and the intersection of the viewer's axis with the picture plane are regarded as the apices of triangles, the resulting figure is not unlike the Euclidean design (Figs. 18c and d). Just as the plan of the architecture is Pythagorean, so is the plan of the figures Euclidean.

Having found both this Pythagorean-Euclidean counterpoint in the architecture and figures of the *School* and a Pythagorean theme in the architecture of the *Disputa*, we would do well to look also for a Euclidean theme in the figures of the *Disputa*. And since there the Pythagorean element is essentially vertical, in contrast to its horizontal manifestation in the *School*, we might expect any Euclidean arrangement of the figures to be vertical also. Including again

the intersection of the center vertical axis with the bottom edge of the painting (this point in an elevation is identical with the intersection of the viewer's axis with the picture plane on a plan), we again find six peripheral points which, considered as the apices of triangles, lead to a design like Euclid's (Fig. 186). And just as Moses with his Ten Commandments sits opposite Pythagoras's numbers, so do we now find David sitting opposite the classical geometer, looking at him as he surveys his two triangles, and realizing, of course, that they form a Star of David.⁴²

Pythagoras and Euclid, then, provide us with a fourfold key to the construction of the paintings—Pythagoras to the architecture, horizontal in the *School*, largely vertical in the *Disputa*; Euclid to the figures, horizontal in the *School*, vertical in the *Disputa*. The Judaeo-Christian scene, primarily vertical, stands in harmonious and amicable dialogue with the classical scene, primarily horizontal, just as Plato and Aristotle conduct their friendly dialogue, the one pointing up, the other ahead.⁴³ In the end the *School* proves to be not only an apotheosis of thought but part of a larger apotheosis of agreement and harmony: in this little room the viewer finds himself equally incorporated in both the heights of Judaeo-Christian revelation and the breadth and depth of the searching mind of antiquity.⁴⁴ Thus did Raphael, fresh from four years of apprenticeship to the Florentines, achieve in Rome the monumental expression of the heritage of Pico and Ficino, of the Florentine faith in the essential harmony of all traditions.

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¹ Leonardo, *Treatise on Painting*, ed. A. McMahon, Princeton, 1956, Vol. I, p. 178; Vol. II, fol. 160; W. W. Bellver, "The Symbolic Architecture of Domenico Veneziano and Piero della Francesca," *Art Quarterly*, XXXVI, 1973, pp. 1-30; "The Blurred Treasure of Titian's Perspective: The Architecture in the *Pala Pieta*," to be published in the acts of the *Convegno "Tiziano e Venezia"*, held in Venice in October, 1976. I am very much indebted to Philipp Fehl, whose suggestion that I study the perspective scheme of the *Pala Pieta* (which it would probably never have occurred to me to do) led me to begin also the work on the other paintings that I had contemplated for some time, to Howard Salsman for his valuable comments on my argument, and to Jerrold Lanes for many editorial suggestions.

² See note 35 below and Fig. 39. I know of no earlier scale drawings than Raphael's for architecture that was to be painted. This is not the kind of drawing that would be likely to survive, and indeed most of Raphael's must have been lost: we have those mentioned in note 35 only because they survived piggy-back on the cartoon for the *School*. Of Domenico Veneziano and Piero della Francesca we have hardly any drawings of any kind—a dozen or so attributed to Domenico and none of Piero's except the illustrations in his *De prospectiva pingendi*. The arguments for the use of architectural plans are, first, that after artists learned how to translate them to a painting in the early fifteenth century, this was the obvious way to obtain an accurate and convincing

ing relation of size and position between nearer and more distant elements; and second, when, having reconstructed a floor plan from some elements in a painting, we use it to predict where other elements should appear on the picture plane, we find that the artist did in fact put them there (W. Bellver, "Symbolic Architecture," p. 28, note 27).

³ Second edition, New York, 1972. See note 6 below and A. Parronchi, *Studi su la delle prospettive*, Milan, 1964, p. 246.

⁴ For previous reconstructions see W. Bellver, "Symbolic Architecture," p. 25, note 3, and p. 30, note 56. Krautheimer, Janson and Jones have used units that might have been used in the fifteenth century; *ibid.*, p. 25, note 4; p. 26, notes 8 and 12; and p. 30, note 57. But only Janson seems to be aware that he might be discovering the artist's dimensions.

⁵ Probably the most important intrinsic tests of the likelihood that a unit of measure has been correctly identified are, first, the prevalence in the dimensions of whole numbers and only the simplest fractions; and, second, the "symbolic appropriateness" of the dimensions to the subject. The reader can judge for himself whether these tests are met by the units of measure postulated here. The most important extrinsic test is the identification of the same or a similar unit of measure in another painting; that the *palaio* gives good results in both the *School* and *Disputa* increases the likelihood that it is correct. For further probative evidence see notes 23 (the scale of Andrea del Sarto's *Cenacolo*) and 35 (Pythagorean numerology; the architectural sketch on Raphael's cartoon; diameters of vaults and of circle at the crossing).

The fact that in all four paintings treated by W. Bellver, "Symbolic Architecture," there appears a foot parallel to the picture plane which serves as a satisfactory unit of measure, means that any three of the paintings are extrinsic tests of the unit used in the fourth. Titian's *Pieta Allapiera* is a striking example of the value of an extrinsic test. The unit of measure appears to be the Roman *piede*, but this is *a priori* most unlikely in a Venetian altarpiece. However, in a smaller altarpiece that Titian painted some years earlier for Jacopo Pesaro, the most likely unit of measure proves to be the Roman *palmus*. Hence we can be more confident that the identification of the Roman unit in the later painting is correct.

⁶ L. Steinberg, "Leonardo's *Last Supper*," *Art Quarterly*, XXXVI, 1973, pp. 346 ("Leonardo's perspective, . . . in Perotti's words, 'has puzzled generations of scholars'"), 372 and 369. This reputation for difficulty seems to me to be undeserved and to tell more about the scholars than the perspective—I have found Raphael's and Titian's paintings far more difficult to decipher. The inhibition regarding measurement and analysis which restrains Steinberg, though reasonable enough as a modern aesthetic preference, is thoroughly unflorentine.

It was a stroke of luck that Steinberg's essay appeared shortly before I began work on the painting: it has a great deal to say about the architectural setting and the site that is new and thoughtful, and I owe much to a dialogue with it. But it is not, I think, a satisfactory interpretation of the painted space for the reason adduced at the beginning of this study as the defect of most such discussions: it does not proceed from an analysis of the perspective construction. The danger in not finding a floor plan and viewing distance at once is that the interpreter will prematurely soar into subjective and mystical exegesis—to paraphrase Leonardo, perspective is a cub for the interpreter as well as for the painter. It is also an invaluable guide and helper, time and again times as far from the work as the "correct" viewing station. This is not to say, of course, that the too-distant view should be ignored, but only that its implications cannot be understood without our knowing where the artist intended that the "correct" viewer should stand. (Steinberg does show a plan in his fig. 39, but it serves only to illustrate the position of the piers at the front corners of the hall, is not accurate even for the rectory, the dimensions of which we know, and is accompanied by no explanation of how the depth of the hall was determined. See note 19 below.)

I precept this critique to the remaining references to Steinberg's essay in order that the reader may understand the point of view, including my feelings of gratitude, from which they are written and because an essay of such importance, and to part of which this study constitutes a *denuit*, deserves a general as well as specific comments.

⁷ I am indebted to Steinberg, pp. 342 and 351, and fig. 33, for the reconstruction of the simulated pilasters at right and left.

We can estimate the width of the hall (equal to 6 coffers) very approximately from the height of the left-

most apostle, St. Bartholomew. On colorplate 55 of F. Hartt, *History of Italian Renaissance Art*, New York, 1969, his half-height is about 45 mm. By the customary rule that a man is 3 *braccia* tall (see note 32 below), a *braccio* at this depth in the painting is 30± mm. long. The far side of the table, at approximately the same depth, is 306± mm. long, or 10+ *braccia*. Allowing a little less than a *braccio* for the space between table and wall (see note 8 below), we get a width of 12 *braccia* for the hall and of 2 *braccia* for a coffer. The doubts that would ordinarily arise concerning so approximate a calculation are in this case forestalled by the extreme likelihood that the length of one side of a coffer would be either a whole number or a mixed number with 1/2 as the fraction. The widths of the hall, resulting from the latter possibility, of 9 (1 1/2 *braccia* coffers) or 15 *braccia* (2 1/2 *braccia* coffers), seem excluded by the calculation based on St. Bartholomew, even taking into account its large margin of error.

The width of the wall is about 8.90 m., which equals 15 Milanese *braccia* of 0.595 m. (8.92 m.). One *braccio* of the painting at the picture plane (8.90÷11) is 0.81 m.

⁸ There is a moderate margin of error in the determination of the depth of the hall: the most accurate way to state it, assuming a viewing distance of 12 *braccia*, would probably be 28.3 *braccia* ± .7. I choose 28 because it avoids fractional coffers and because 29, having no factors, is not reducible to simple proportions. The dimensions of the refectory (8.87 × 35.5 m.) are given by L. Heydenteich, *Leonardo: The Last Supper*, London, 1974, p. 16.

The size and location of the table have always posed a problem, many scholars—most recently and particularly Steinberg (p. 303, but see p. 351)—maintaining that the space between it and the walls is too small to accommodate the figures which seem to occupy it. Steinberg is mistaken in thinking that Möller's diagram (Steinberg's fig. 5) demonstrates that "the extremities of the board run so close to the side walls that they leave insufficient floor space for St. Simon's seat at far right . . ."; this conclusion overlooks the possibility that the board extends nearer to the picture plane than the trestles. As Leonardo writes, "L'occhio non può giudicare dove la cosa alta deve discendere" (Jean Paul Richter, *The Literary Works of Leonardo da Vinci*, 2nd ed., London, 1939, no. 105). To calculate the position of the board we can begin with the legs of the trestles: if their original position has survived the mutilation of the painting, then they are some 1 1/2 *braccia* beyond the picture plane. One of the most authoritative copies shows the hanging tablecloth casting a shadow on the trestles almost halfway from the cloth to the floor (Steinberg, p. 345, fig. 27; cf. fig. 31). Assuming a source from which light would fall on the table at an angle of about forty-five degrees from the vertical (as light coming from the nearest refectory window would do), the shadow indicates that the table projects about 1/2 *braccio* forward of the legs of the trestle (see Fig. 9). Consequently, on the assumption that the near edge of the table is one *braccio* beyond the picture plane, its length proves to be approximately 10 1/2 *braccia*, and each of the two figures at its ends has available some 1/2 *braccio* of space—about 19 inches or 48 cm. in our scales. This is not generous, to be sure, but it is enough to make the relation of table, disciple and wall a rational one and so to avoid the impasse which has troubled previous scholars. From the length of the table, its width can be calculated as about 2 1/2 *braccia*; thus its proportions are 1:4, the same as those of the refectory.

⁹ S. Spirito (Oragna?), S. Croce, S. Apollonia (Andrea da Castagno), Ognissanti (Ghirlandaio), S. Marco (Ghirlandaio), S. Onofrio (called di Foligno; Perugino); see L. Vertova, *I cenacoli fiorentini*, Turin, 1965.

¹⁰ Since writing this study I have seen C. Gilbert's article, "Last Suppers and Their Refectories," in *The Pursuit of Holiness in Late Medieval and Renaissance Religion*, ed. C. Trinkaus, Leiden, 1974, pp. 371ff. Gilbert also remarks the frequency of paintings of the Last Supper in Florentine refectories, reasons that they were intended to prolong realistically the space of the refectory (p. 372), and notes the large number of meals depicted on the end wall of the S. Croce refectory (p. 376).

¹¹ Approximate ratios of length to width are: S. Apollonia 3, Ognissanti 4, S. Onofrio 4.3, S. Maria delle Grazie 4.

¹² Two objections to a vanishing point below the floor of a painting are, that the deeper the figures stand within the painted space, the higher are their bodies cut off by the front edge of the floor, and that the viewer's inability to see the whole scene dampens his sense of presence at, or participation in, it. The conventional solution was to draw the scene as if the viewer's eye were some distance above the floor of the painting (at the point to which cameras are elevated for modern photographs), even though this might be far above the point from which he would actually look.

¹³ Perugino further disguised the corners by keeping the change in value and color to a minimum.

¹⁴ In Andrea's painting the space of almost one m. between the side walls of the painting and of the refectory is taken up by the face of a pilaster and by a simulated brick wall parallel to the picture plane.

¹⁵ The width of Andrea's painting is 7.94 m. (the interior of the painted room), the viewing distance about 22.3 m., the length of the refectory 28.1 m. (for my method of calculating a viewing distance, see note 33, third paragraph, below). White, pp. 198f., followed by Hartt, pp. 222f., asserts that it is impossible to calculate a viewing distance for Andrea's painting because there is no convincing indication of the depth of the room in relation to its width. But there are three indications that it is twice as wide as it is deep: the number of loops in the frieze decoration (noted by White), the number of sagging curves in the cloth tacked up behind the diners, and the number of figures which could be accommodated on the side benches. The failure of the ceiling rectangles to diminish in apparent depth as they recede, noted by Hartt, approximates the real impression made by equal divisions of a shallow foreshortened surface seen from a great distance. Gilbert (pp. 378f.) discusses Andrea's perspective arrangement and makes some observations similar to mine, except as regards the viewing distance, which he appears to estimate instead of calculating.

¹⁶ The width of Ghirlandaio's painting is 8.12 m., the viewing distance about 13 m. and the length of the refectory 32.3 m.

¹⁷ The width of Perugino's painting (measured from one refectory wall to the other) is 8.10 m., the viewing distance about 7.5 m. and the length of the refectory 34.5 m.

¹⁸ Steinberg, pp. 355-60, sees this clearly but does not, I believe, correctly recognize its implications because of his failure to distinguish between the "correct" and the too-distant viewer.

¹⁹ That a normal head with long hair should obscure half the width of a doorway such as this requires that the viewer be no more than one-third as far from the head as the head is from the doorway. Admittedly, the viewer cannot easily judge the latter distance, but the tapestries on the side walls give him an approximate idea: they are a little less than 8 Milanese *braccia* high, from this dimension their width can be estimated as 5 to 7 *braccia* (on the assumption that they are oblong and hung vertically), and hence, allowing for a space between them of half their width, the depth of the hall could be conjectured as between 27 1/2 and 38 1/2 *braccia* (Steinberg, fig. 39, chooses a depth of 31 *braccia*). Taking the mean of 33 *braccia* and assuming that Christ sits 5 *braccia* beyond the picture plane, we get a viewing distance of 3 1/2 Milanese *braccia*. Even for a head 3/4 normal size (which is about what Christ's proves to be), the viewing distance should be no more than 13 Milanese *braccia*. But at the far end of the refectory the viewer is some 60 *braccia* from the painting—over twice as far from Christ as Christ is from the doorway—and the head will seem three times life size. If such reasoning seems more conscious and complex than that which viewers are likely to indulge in, it must be remembered that Leonardo painted primarily not for viewers like ourselves, who see the work only occasionally, but for those who would see it two or three times a day for years on end.

²⁰ Cf. Fig. 4. When it was clearer than it is now that the painted hall is a little wider than the refectory, this opposite behavior of real and painted side walls may have been slightly less disturbing to the lateral viewer.

²¹ See Steinberg, pp. 352f. and fig. 38. In Leonardo's time the interruption of the wall orthogonals was even harsher, if the floor level was then one m. lower than at present; E. Müller, *Das Abendmahl des Leonards*, Baden-Baden, 1952, p. 50, fig. 49.

²² Eva Borsook (*The Mural Painters of Tuscany from Cimabue to Andrea del Sarto*, London, 1960, p. 159) estimates the figures in Ghirlandaio's Ognissanti *Cenacolo* to be one and one-half times life. Of course, any such estimate depends on the method of calculating the height of a standing figure and on what one assumes life scale to be. I estimate Judas's height (standing) to be 1.83 m.; converted to height at the picture plane this comes to 2.17 m.; and this is 1.24 times the 3 *braccia* (69 in.) which was a rule of thumb for a man's height (see note 32 below).

²³ The dimensions of the space in Andrea's, Ghirlandaio's, Perugino's and Leonardo's *Cenacoli*, all in *braccia* of the painting, are (depth first): Andrea, 7 by 14; Ghirlandaio, 9 by 15; Perugino, 12 by 12; Leonardo, 28 by 12. The proportions of the space in the four paintings of Domenico Veneziano and Piero della Francesca treated by Welliver, "Symbolic Architecture," are 7 by 4, 2 by 1, 3 by 1 (left side only of *Flagellation*), and a little greater than 3 by 1.

If in Leonardo's *Annunciation* (1475-78) we make the lines of the floor pattern continuous, assume the resulting quadrangles to be squares, take the side of a square as the unit of measure, and assume its length to be one-sixth *braccia*, we obtain the following distances: viewer to picture plane, 3 *braccia*; viewer to near side of wall, 9; viewer to far side of wall, 13.5 (it comes as a surprise to find that the wall would be 2.6 m., or 8 1/2 feet, thick in life scale). The lateral distance from the building at the right to the left end of the wall (just to the right of Gabriel's hand) is 6 *braccia*. Prolonging the left end of the wall through the picture plane, the plan is divided into three rectangles: viewer to picture plane, 3 by 6=18 square *braccia*; picture plane to wall,

parity might well cast doubt on the accuracy of the reconstructed plan, were it not that an anomaly in it betrays a difficulty that must have arisen as a result of enlarging the upper floor. The space between pilasters on the foreshortened walls of the pylons should be as wide as that on the front walls, since both contain niches and statues of the same height and presumably the same width. On the front walls this space is $7\frac{1}{2}$ *palmi* wide, but on the side walls only $4\frac{1}{4}$ (a wall of 8 *palmi* less pilasters of $2\frac{1}{4}$ and $1\frac{1}{2}$ *palmi*). Obviously a niche and statue designed for a $7\frac{1}{2}$ -*palmi* space cannot fit into $4\frac{1}{4}$ *palmi*. It seems a reasonable inference that between drawing and painting Raphael decided to deepen the floor by 7 *palmi* and was able to gain part of this additional depth by reducing the size of the pylons, but was unwilling to gain the rest and provide the proper interpilastral space by moving the front of the gallery $3\frac{1}{4}$ *palmi* back, because this would have disrupted his modular scheme.

Why deepen the floor? Perhaps to give the figures more space and, by moving the pylon back and reducing its width, to gain room beneath the frame for the statues of Apollo and Athena (hence the importance of *l'altezza*) and reduce the mass and prominence of pylons extending all the way to the side frames. (For other changes from the sketches or cartoon and other anomalies in the architecture, see the last three paragraphs of this note.)

The second consideration that supports the accuracy of the present reconstruction is the fact that the barrel vaults and the circle at the crossing turn out to have diameters of 28 *palmi*. From at least the time of Brunelleschi and Masaccio, it seems to have been thought desirable that the diameters of circles and semicircles should be integral multiples of 7. The reason for this is obvious: before the advent of decimals the value used for π was $22/7$; hence, if the diameter of an arch or circle was divisible by 7, its circumference proved to be a multiple of 11. In particular, if the diameter of an arch, say, was 21, its circumference was 33, a most appropriate dimension for a Christian arch. (See Welliver, "Symbolic Architecture," p. 18 and note 55. The diameters of the circles and arches at the crossing in Brunelleschi's S. Lorenzo and S. Spirito are about 21 *braccia*. The diameter of the cupola in the Pazzi Chapel is about $17\frac{1}{2}$ *braccia*, which results in a circumference of 55 *braccia* for the base of the cupola and 27 $\frac{1}{2}$ *braccia* for the arches, doubtless thought of as 27, or 3^3).

In the present case the circumference of the arch is 44 *palmi*, or (the *palmi* equalling $\frac{1}{4}$ *pie*) 33 *pie*, and the circumference of the circle at the crossing is 88 *palmi* or 66 *pie* or, to use the Florentine unit of measure, 33 *braccia*. The center of this circle is 11 *palmi* from the viewer, and Plato's one straight index finger is pointing (two-dimensionally) at the corresponding center of the dome. In reconstructing the architecture we have gone from the $4\frac{1}{2}$ *palmi* by $4\frac{1}{2}$ *pie* floor rectangles at the bottom of the painting, at which Aristotle's (in a sense) $4\frac{1}{2}$ fingers are pointing, to the unity at the center of the mystic 33-*braccia* circle, to which Plato is urging us at the top. (The right hands of Plato, whose head is thought to be a portrait of Leonardo, and of Aristotle may be quotations of the right hands of Thomas and Christ in the *Cenacolo*.)

Other changes besides that of the pylons were made between sketches and painting: the risers of the steps were increased from $\frac{1}{4}$ to one *palmi*, and oblique *pilastroni* at the crossing, to be seen in one of the sketches, are not found in the painting (pace Oberhuber, p. 36). One change occurred even after the cartoon: on the right third of it a floor pattern of small squares is drawn, similar to the floor in the adjoining scene, *The Laws*, on the south wall of the room. The interval between orthogonals in this pattern at the depth of the rightmost foot in the scene, which is at the bottom of the cartoon, is about 24.5 cm. and would be about 27 cm., or one *palmi*, at the baseline. Since the floor pattern, like the rest of the cartoon, is pricked for transfer to the wall by *spolvero*, we must assume that it was painted and later erased. A likely explanation for this change is that Raphael had virtually decided on a rectangular pattern similar to that in the already completed *Disputa*, but wished to see a sample of this variant before the final decision. The variant not satisfying, he erased it and painted the present rectangles, but then found them and the vacant center foreground so repetitive of the *Disputa* that he inserted the huge figure of Michelangelo, which is not in the cartoon.

The crossing, like the pylons, is anomalous in the extreme. The section of foreshortened circle immediately above the vault and medallions implies a dome with a base wider than the width of the vault. Barring the unlikely case of an elliptical dome, this would mean that the distance between the two vaults shown in the painting should be greater by the same amount than the width of a vault (28 *palmi*); but the floor plan shows it to be equal to the width of a vault. Furthermore, the medallions in the spandrels (as well as the wider dome) imply the presence of the oblique *pilastroni* which were eliminated between sketches and painting. As things are now, the bases of the spandrels—the only supports of the dome—would themselves have no support a short distance to the right or left of the arch.

The anomalous pylons and crossing suggest that three trains of thought combined and were reconciled to

reach the final solution: (1) the free and preliminary sketches of the desired architectural forms (Oberhuber, illustrations xxx-xxxii); (2) the requirements of the two-dimensional composition; and (3) the modular floor plan which, once determined, remained intact. The pylons were treated as described above, Fig. 19 being part of the reconciliation of (1) with (2). At the crossing, the 28-*palmi* square of (3) would require that the lateral vaults spring from the same points as the longitudinal vaults; but this would spoil the light and spaciousness desired at the crossing and so foreshorten the medallions as to render them almost useless for decoration. Therefore (as with the pylons) Raphael left the essential floor plan unchanged but painted spandrels of a dome wider than 28 *palmi* and, contradicting these, lower walls perpendicular to the gallery which would both catch full light (in other words, spandrels and a dome which the floor plan did not permit and lower walls which would not support them).

³⁶ The title is derived from Vasari's mistaken description of the subject as a dispute ("tutti i savi del mondo che disputano . . ."); Vol. II, pp. 133f.

³⁷ I assume the floor rectangles to be 3 *palmi* deep by 4 wide (the same proportion as in the *School*) and obtain a viewing distance of 27 *palmi*. This equals 6.97 m. (one *palmi* equals .258 m.) and is consistent with the viewing distance for the *School* of 6.75 m. and with the distance from the painting to the putative bookcase along the opposite wall of about 7.65 m. Distances from the viewer are: to the bottom step, 33 *palmi*; to the upper floor, 37; to the altar, 43. The altar is 4 *palmi* high by 6 wide; 2 *palmi* would be a reasonable depth (proportions of 3:2:1); hence the host placed at the center of the table would be 44 *palmi* from the viewer.

With a little imagination and a few sketches it is easy to see how the half-ellipse of the saints and prophets, the half-circle around Christ, and the half-figure of God the Father could have evolved from the drum, the dome and the lantern of a cupola. Thus the forms of the upper part may resemble the central element in the architecture of the *School*, just as the lower part resembles its foreground.

The conical shape suggested by the rays of the sun reinforces the roundness of the celestial architecture. The rays converge at a point about 28 *palmi* above the floor.

³⁸ Deut. 4:13. Henry Fischel has kindly examined the painted text and says that, as is usually true of Hebrew inscriptions in paintings of this epoch, it makes no sense. He also tells me that it is usual in synagogues—presumably this was true also in Raphael's time—to display two such tablets, each with a word or two on five lines standing for the Commandments. On each of Raphael's tablets there are five full lines of characters (counting a line beneath Moses's left hand), although the tops of a few characters in sixth lines can be seen above his robe.

³⁹ All the ratios in Pythagoras's table of the musical tones can be formed from the floor rectangles of both paintings as follows:

6:8, diatessaron	four rectangles, <i>Disputa</i>	6×8 <i>palmi</i>
6:9, diapente	two rectangles, <i>School</i>	6×9
6:12, diatason	six rectangles, <i>Disputa</i>	6×12
8:9, epogdoon	six rectangles, <i>Disputa</i>	8×9
8:12, diapente	eight rectangles, <i>Disputa</i>	8×12
9:12, diatessaron	four rectangles, <i>School</i>	9×12

The rectangles themselves, 3 by 4 *palmi* in the *Disputa* and $4\frac{1}{2}$ by 6 in the *School*, are reductions of the two ratios of the diatessaron.

⁴⁰ S. Valtieri interprets this passage as Bramante's illustration of a new method for drawing architecture in perspective; "*La Scuola d'Atene*: 'Bramante' suggerisce un nuovo metodo per costruire in prospettiva un'architettura armoniosa," *Mitteilung des Kunsthistorischen Instituts Florenz*, XVI, 1972, pp. 63-72. Vasari says that the figure may be a portrait of Bramante; Vol. II, p. 134.

⁴¹ Two of the omitted pairs of figures have the obvious function of defining the corners of the pylons. Of the other two, one is in the right distance, facing somewhat away from the viewer, and the other is just to the right of, and beyond, Socrates.

⁴² Both Moses and David are in the fourth place from the end of the semicircle of figures. The six-pointed star was not an exclusively Jewish symbol in antiquity: the earliest denomination of the device as the Shield of David is to be found in the tradition of Jewish Cabala and magic in the fourteenth century; G. Scholem, "*The Curious History of the Six-Pointed Star*," *Commentary*, 8, 1949, pp. 243-51. As a symbol of Jewish magic and mysticism, it is well paired with the numbers and musical ratios of Pythagoras.

⁴³ It is often said that Plato and Aristotle are walking together. In fact only Plato is walking; Aristotle, unlike his disciples, is clearly not peripatetic. Perhaps the contrast in their movement, no less than that between their

vertical and horizontal gestures, was meant as a symbol of the difference between the two philosophies.
44. What a perfect foil for the spirit of family and optimism pervading the works is the brooding giant, Michelangelo, the solitary pessimist at work (in life) on the profoundly pessimistic Statue Ceiling!

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