Vermeer in Perspective

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"KNOWLEDGE BECOMES THE PAINTER," Samuel van Hoogstraeten wrote in his 1678 *Inleyding tot de hooge schoole der schilderkonst* (Introduction to the School of Painting).[1] Clio, muse of History, is depicted at the beginning of the chapter on the image and poetic inventions (*Poetische verdichtselen*). More than ten years earlier, Vermeer had used Clio in his *Art of Painting*, in which he demonstrated not only his learning as a painter and inventor of allegories, but also, as we will see, his knowledge of perspectival theory.

In this large painting a heavy curtain appears to be held aside by an invisible hand: the viewer is invited to enter the painter's studio. The artist is seated, with his back toward us, and on his easel, on a grounded canvas, is an unfinished half-figure of Clio, sketched in white. The size of the canvas would not allow for a larger figure, nor for the trumpet of Fame, usually held by Clio.

The artist has started to paint at the top of the canvas. He seems to have finished the flesh colors and has begun to lay in the leaves of the laurel wreath. It looks like the painter—as pictured by Vermeer—is following tradition by finishing one area before setting up a new palette for the next area.[2] A similar technique can be seen in *Saint Luke Painting the Virgin and Jesus* (fig. 1) by Maerten van Heemskerck (1498–1574). In that work Saint Luke, patron saint of painters, is applying the flesh color of the Child, while the hair and flesh colors of the Virgin are already finished. The rest of the composition is still only a rough sketch.

The general similarities between the two paintings by Van Heemskerck and Vermeer seem to acknowledge sixteenth- and seventeenth-century traditions in painting methods. Saint Luke applies the paint to a panel with a white ground, as was customary in the sixteenth century. The painter in Vermeer's *Art of Painting* (fig. 2) used a colored ground, just as Vermeer did in the majority of his works. Examination shows, however, that Vermeer himself worked areas up 'side-by-side' rather than 'piece-by-piece.' Instead of documenting his particular painting methods, Vermeer's *Art of Painting* was probably intended to emphasize contemporary accomplishments and to pay tribute to his predecessors, and hence to artistic tradition.

fig. 1. Maerten van Heemskerck, *Saint Luke Painting the Virgin and Jesus*, c. 1550, oil on panel, Musée des Beaux-Arts, Rennes

Detail, cat. 19

The Use of Central Perspective

A closed, bound book stands on end on the table in the middle ground of the *Art of Painting*, and an open book in folio appears at the right edge of the table, next to the painter's elbow. The inventory of Vermeer's estate, made in February 1676, lists a number of books in folio in a back room, and twenty-five other books of various kinds.[3] It is conceivable that some of these were guides to perspective drawing, like the one by Hans Vredeman de Vries (1526/1527–1606) or the books published by Samuel Marolois (c. 1572–c. 1627), Hendrick Hondius (1573–1649), and François Desargues (1593–1662).[4]

Vermeer was familiar with the principles of perspective described in these manuals, as can be seen in his paintings. Remarkably, thirteen paintings still contain physical evidence of Vermeer's system, by which he inserted a pin, with a string attached to it, into the grounded canvas at the vanishing point.[5] With this string he could reach any area of his canvas to create correct orthogonals, the straight lines that meet in the central vanishing point (fig. 3). The vanishing point of the central perspective in the *Art of Painting* is still visible in the paint layer just under the end of the lower map-rod, below Clio's right hand.[6]

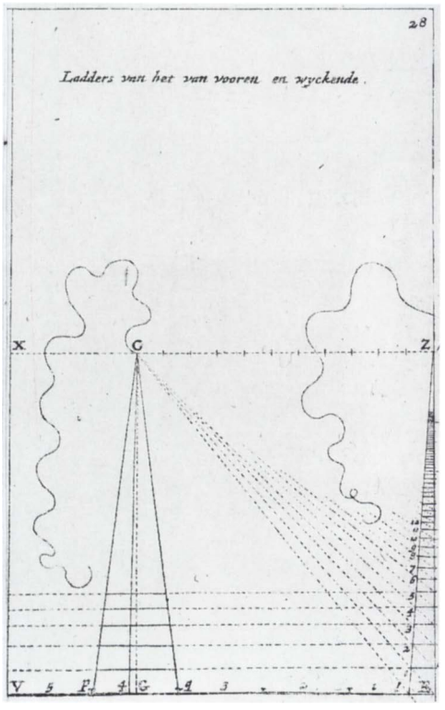
To transfer the orthogonal line described by the string, Vermeer would have applied

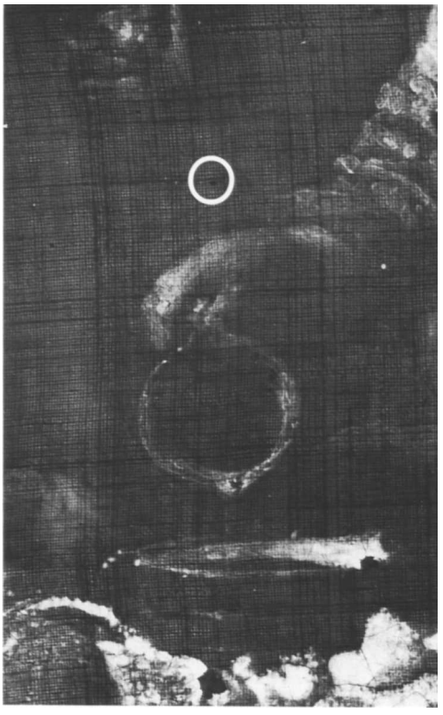
fig. 2. Johannes Vermeer, *Art of Painting*, c. 1666-1667, canvas, Kunsthistorisches Museum, Vienna

chalk to it. While holding it taut between the pin in the vanishing point and the fingers of one hand, his free hand would have drawn the string up a little and let it snap back onto the surface, leaving a line of chalk. This could then have been traced with a pencil or brush. Such a simple method of using a chalk line to make straight lines was probably used by Vermeer's Delft colleagues Leonard Bramer (1596–1674) and Carel Fabritius (1622–1654) to compose wall paintings, and is still used today by painters of *trompe l'oeil* interiors.[7]

Little or no trace of Vermeer's method – except the pinhole – remains. This is visible to the naked eye on Vermeer's *Allegory of Faith* (cat. 20). Since almost all of Vermeer's grounds contain lead white, the loss of ground where the pin was inserted usually appears on the x-radiograph as a dark spot (fig. 4).[8] This method of placing a pin through the canvas was not unique to Vermeer, but was in fact widely practiced among architecture painters of his time. It was used not only by Gerard Houckgeest (c. 1600–1661) and Emanuel de Witte (c. 1617–1692), but also by Vermeer's slightly older colleague Pieter de Hooch (1629–1684), a painter of interiors. Similarly, pictures by the genre painters Gerrit Dou (1613–1675), Gabriël Metsu (1629–1667), and others, also have irregularities in the paint surface where a pin was placed at the vanishing point.

Like most of his contemporary painters, Vermeer created the spatial illusion directly on the canvas. The Haarlem painter Pieter Saenredam (1597–1665) practiced another method. On the basis of a preparatory sketch, observed first-hand, Saenredam con-





LEFT: fig. 3. *The construction of receding lines*, from Bosse 1684, no. 28, Koninklijke Bibliotheek, The Hague. *X-Z* is the horizon, *C* the central vanishing point. Note the loose ends of the string used for the construction.

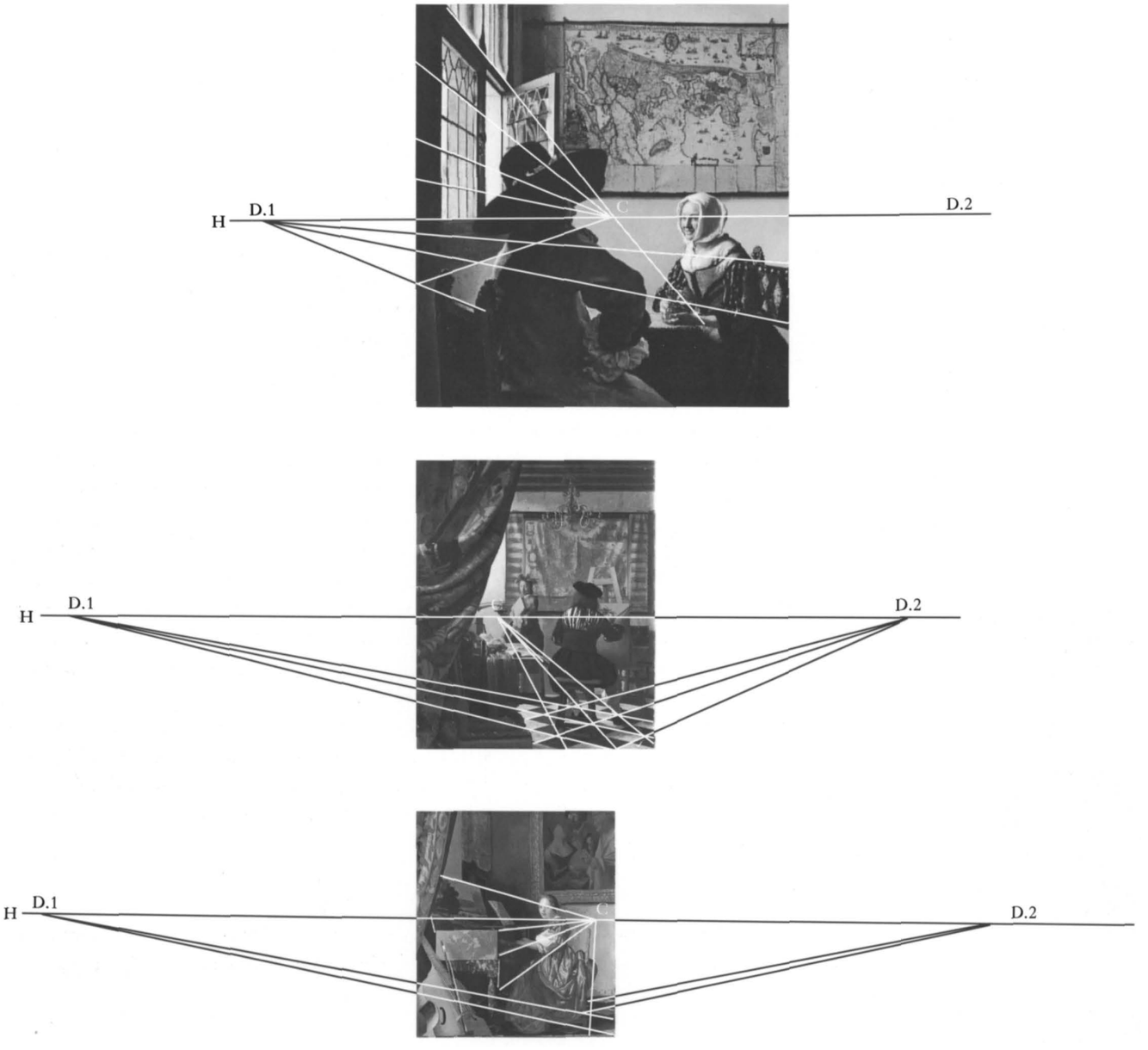
RIGHT: fig. 4. X-radiograph detail of cat. 5, showing the pinprick by which Vermeer constructed the painting's perspective

structed his perspective on a sheet of paper, later, in his studio. After having reached the final composition he would apply charcoal on the back of the paper and transfer the drawing with a sharp tool onto the surface of a prepared panel. After this the painting process could start.[9] Saenredam always used a panel support, while Vermeer apparently preferred to work on canvas.

Vermeer's Methods

In the beginning of his career Vermeer had difficulty in rendering floor tiles. The distance points, positioned at an equal distance on either side of the vanishing point on the horizon, provided the basis for the diagonals. These lines form the pattern of the floor tiles. When the horizon of his painting was relatively high and the distance points were close to the vanishing point, Vermeer apparently was vexed by the distortion of the tiles at the foreground corners. Examples of this occur in his earlier paintings such as *The Glass of Wine* (page 36, fig. 7; c. 1658–1660) and *The Girl with the Wineglass* (c. 1659–1660, cat. 6). The last example in Vermeer's oeuvre that shows a certain distortion of the floor tiles owing to the short interval between the distance points is *The Music Lesson* (c. 1662–1664, cat. 8). Here the view point, the center of projection,[10] is situated about 77 centimeters from the painted surface, the so-called picture plane. Viewed from this distance, the distortion is not noteworthy.

As Vermeer's career progressed, he solved this problem by moving the distance points farther away from the scene, thereby eliminating the distortion. This is important, particularly as he moved his vanishing point toward the edge of the painting at the same time. In *Officer and Laughing Girl* (c. 1658), the viewing angle[11] is about 53° (fig. 5a) and in



the *Art of Painting* (c. 1666–1667) the viewing angle has come down to around 30° (fig. 5b). In *The Love Letter* (c. 1669–1670, cat. 18) the angle declines to about 28°, and in the last painting executed by his hand, *A Lady Seated at the Virginal* (c. 1675, cat. 22), Vermeer reduces the viewing angle to only 22° (fig. 5c). It is interesting to note that Vermeer painted only diagonally placed floor tiles in his interiors, while De Hooch used diagonally placed as well as parallel tiles–sometimes even both within one painting–at random intervals.

Although Vermeer seems to have consistently used a string attached to a pin placed in the central vanishing point, the placement of the distance points poses a problem. At first one might expect that Vermeer determined the position of the diagonals on the edge of his canvas with the aid of a so-called "height wall" (*hoogte muur*), as some Dutch landscape painters did.[12] This would imply doing calculations or constructing of auxiliary lines in order to make space recede toward the back wall. Since no trace of marks on the edges or elsewhere on his paintings has so far surfaced, it seems highly unlikely that Vermeer used such methods.

Painters would want to create perfect central perspective without having to struggle

TOP: fig. 5a. Perspective diagram of Vermeer's *Officer and Laughing Girl*. This is the earliest painting where the vanishing point has been detected in the paint layer. Owing to the short interval between the central vanishing point and the distance points, the viewing angle is about 53°.

CENTER: fig. 5b. Perspective diagram of Vermeer's *Art of Painting*. The viewing angle has decreased to approximately 30° as the interval has lengthened between the central vanishing point and distance points.

BOTTOM: fig. 5c. Perspective diagram of *A Lady Seated at the Virginal*. In this painting, probably the last one executed by Vermeer, the viewing angle is only 22°.

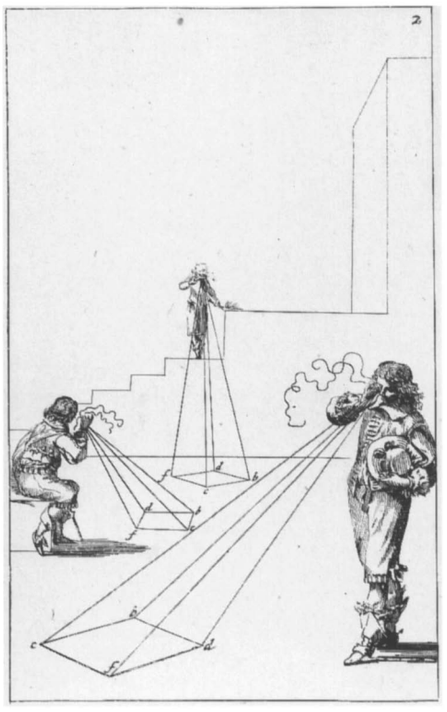


fig. 6. *The visual rays of sight*, from Bosse 1684, no. 2, Koninklijke Bibliotheek, The Hague

with complicated theories. One simple way was to use the already mentioned chalk line to determine the orthogonals, a method that Vermeer could apply to the diagonals as well. It can be assumed that Vermeer placed his canvas—usually small—against a board or a wall, with a nail on either side of the painting. These nails would be placed at the same level as the horizon in the picture. With strings attached to the nails Vermeer could again apply the chalk line for the diagonals in his constructions. The use of this simple method can be deduced from various manuals on perspective that Vermeer could have known. One such manual shows strings, held taut to one eye, attached to a square lying on the ground (fig. 6).

Strings were also used in connection with drawing tables. In contrast to what we expect, it appears that constructors of perspective in the seventeenth century used drawing tables almost as sophisticated as the ones in use today (fig. 8). With strings attached to movable devices placed at the upper corners of the drawing table, the draftsman could create any desired diagonals or orthogonals on paper. The horizon could be plotted using a sliding ruler at a fixed 90° angle to the horizontal bottom edge of the table. A horizon would be chosen at the desired level on this ruler, and by sliding the ruler across the paper a line could be drawn.[13]

Just how painters exercised the perspective can be seen in a charming sketch drawn on the wall behind the painter depicted at his easel by Barent Fabritius (1624–1673) (fig. 7).[14] In red chalk, among cartoons, the draftsman has made a spatial study with a distinct vanishing point in the middle. The orthogonals and also some of the diagonals have been drawn in.

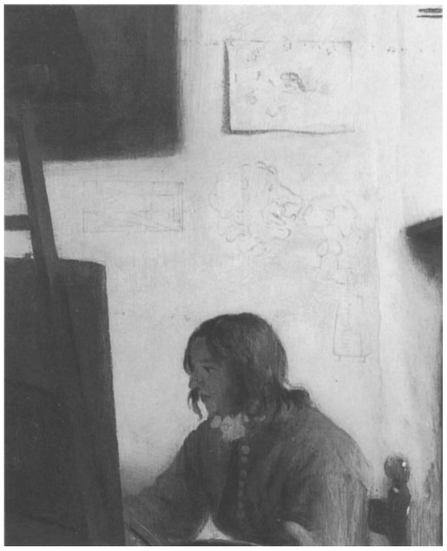


fig. 7. Detail, Barent Fabritius, *Young Painter in His Studio*, c. 1655, oil on canvas, Musée du Louvre, Paris

Construction

In 1669 Pieter Teding van Berckhout, a prominent citizen of The Hague, visited Vermeer's studio and described the paintings that he saw as extraordinary and curious "*perspectives.*"[15]

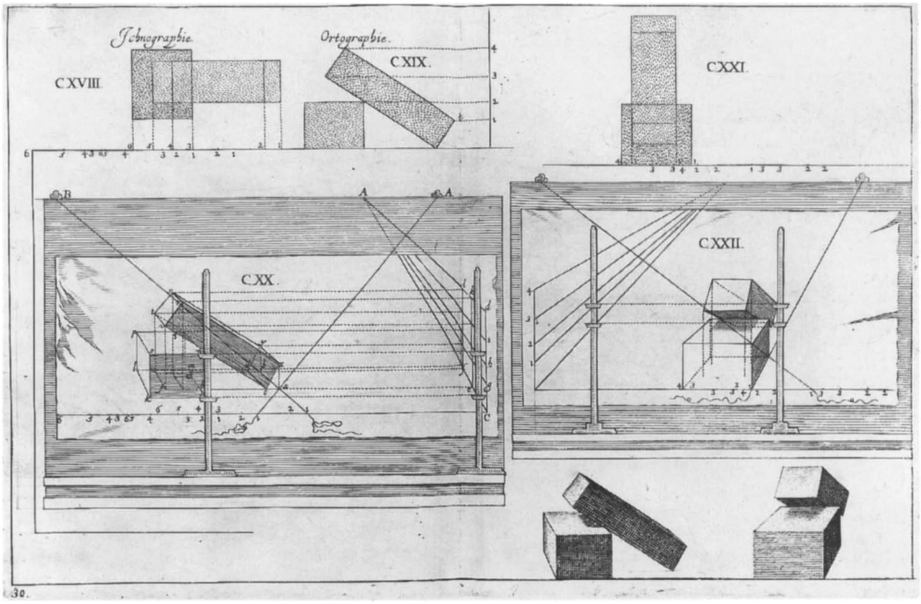


fig. 8. Hendrick Hondius, *Drawing table*, from Marolois 1628, no. 30, Koninklijke Bibliotheek, The Hague

Teding van Berckhout might have referred to Vermeer's interior scenes, which were very carefully constructed. This leads us to the conclusion that Vermeer should be considered first and foremost as a practical and skilled master in creating his interiors just the way he wanted them. Numerous authors have argued that the artist reproduced the scenes he saw in front of him, either by careful copying, using drawing frames, or by means of a camera obscura.[16] That Vermeer traced an image with this device is unlikely; however, a number of paintings are believed to have been created with the camera obscura as a compositional aid.[17] The way Vermeer occasionally applied the final paint layer or highlights in a pointillistic manner may have been influenced by the vision one gets by looking through a camera obscura (but see page 25).

Vermeer was completely aware of the spatial illusion he wanted to create, which he accomplished by combining his skill in constructing space with his talent for composition, color, technique, and iconography. Without the use of a camera obscura as a drawing aid he created images that looked "photographic," which deceive the spectators into *believing* that the scenes are real. With this illusionism Vermeer attained the highest level of artistic ambition to which a seventeenth-century painter could aspire.[18]

Since Vermeer created his compositions very carefully, one must ask if the figures and the many accessories in the paintings were also constructed. Close study of the foreshortened furniture has revealed that it has been just as carefully built up as the overall perspective. Once again, the chalk lines attached to the distance points formed by the nail in the wall next to the picture would have served as the base for the receding lines of the chairs and tables in Vermeer's interiors (fig. 9).

The horizon in Vermeer's earlier paintings in general (cat. 2 and page 20, fig. 6) is observed to be relatively higher than in the later ones. Although high horizons also occur in later works, the position of the horizon in combination with the viewpoint of the spectator is significant.[19] In the majority of Vermeer's works the viewpoint is indeed below the eye level of the depicted figures. It has been argued that when using a camera obscura placed on a table, the artist's vantage point would naturally be low.[20] However, Vermeer may have deliberately sought this effect, in order to keep the spectator at a distance. As

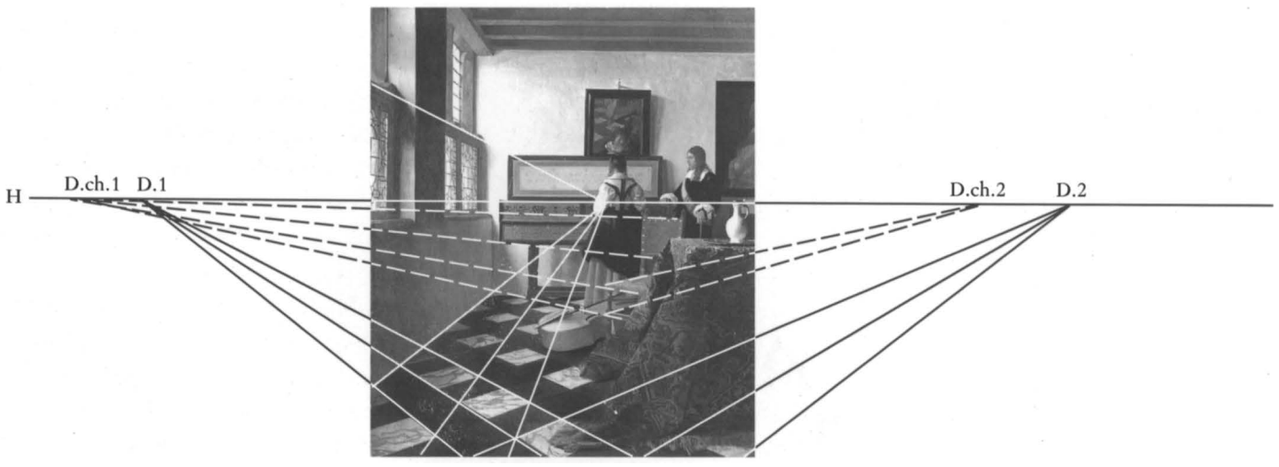
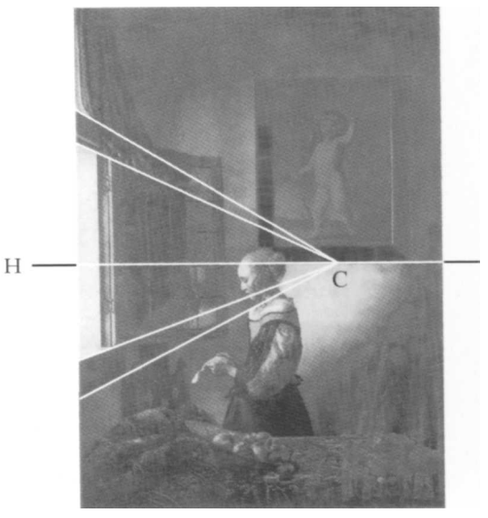


fig. 9. Perspective diagram of cat. 8. The distance points of the construction of the chair are marked *D.ch.1* and *D.2*. Both points are carefully placed at an equal distance to the left of the distance points (*d.1* and *d.2*) of the overall composition.



TOP: fig. 10. Reconstruction of fig. 11

RIGHT: fig. 11. Johannes Vermeer, *Girl Reading a Letter at an Open Window*, c. 1657, oil on canvas, Staatliche Kunstsammlungen Dresden, Gemäldegalerie Alte Meister

we almost always have a frog's eye view, from below, the figures automatically increase in stature, even in a small painting such as *The Milkmaid* (cat. 5).

Vermeer also deliberately places the vanishing point behind a *répoussoir* or other barrier between the viewer and the scene. This seems to have been a hallmark throughout his oeuvre as seen in paintings from the *Procuress* (page 60, fig. 16) and *Girl Reading a Letter at an Open Window* (fig. 11) to the *Art of Painting* (fig. 2) and *The Love Letter* (cat. 18).

In the early *Girl Reading a Letter at an Open Window* the horizon is placed in such a way that it divides the painting in half. The vanishing point is placed between the girl's neck and the green curtain to the right. The reason for the position of the vanishing point behind the reading girl seems irrational, as it does not lead the eye of the spectator into the composition. At an early stage in the development of this picture, however, a painting of Cupid hung just above the vanishing point on the back wall.[21] To stress the amorous content of the letter, the orthogonals to the vanishing point would lead the eye of the spectator via the Cupid to the girl and back, which would be logical (fig. 10). But Vermeer has obscured the meaning by overpainting the Cupid, and leaves us only with a very naturalistic and sensual reflection of the girl in the leaded glass window. Despite the changes that Vermeer made to the composition, he did not alter the perspective design.

Acquiring Expertise

Where or with whom Vermeer trained in the use of perspective is entirely unknown. In the introduction of his book on perspective, Desargues writes that a painter who wants to know more about the *Meet-konst* (art of measurement) should consult the *Landmeeter* (cartographer) in order to make use of his expertise.[22] According to Desargues this would lead to a better understanding of *Doorzicht-kunde* (perspective). He further suggests that the painter should look around him at other crafts and take advantage of the knowledge of, for instance, carpenters, bricklayers, and cabinetmakers.[23]

A painter like Saenredam acquired his first instruction in the rules of perspective from the local *landmeeter* (cartographer) Pieter Wils, when he was already established as an artist.[24] In Haarlem this profession was included in the painter's guild of Saint Luke, and also in Vermeer's home town of Delft one could receive education in this *métier.* At the age of thirty-six Anthony van Leeuwenhoek, who may have known Vermeer, obtained his diploma in cartography in Delft—that is, when Vermeer had already made a number of 'perspectives.'[25] The knowledge of perspective was essential to the succesful creation of a correct spatial illusion, which was so popular with Delft painters after 1650. The importance of good training was stressed by Van Hoogstraeten, who explained that without this learning, "so many ignorant painters are shipwrecked."[26]

It was only after some years of practice that Vermeer became an expert in the use of perspective. In his early work, such as *Christ in the House of Mary and Martha* (cat. 2), the interior does not have a correct and carefully constructed perspective. Nor do his following paintings, including *A Woman Asleep* (page 20, fig. 6), which is an ambitious attempt to create a literal "Through-view" (*Doorzicht*). Around 1658 Vermeer's interest changed into creating space in a carefully constructed way. This resulted in the *Officer and Laughing Girl* (page 35, fig. 6), the first painting where Vermeer employed a string attached to a pin. Throughout the rest of his career he continued to use this method.

Vermeer's Studio

In order to visualize Vermeer's studio we have to look at written sources and his paintings other than the *Art of Painting*, from which little can be deduced. There the painter steadies his right hand, resting it on a maulstick held in his left hand. No other painting materials or accessories other than the maulstick, and the brush are present.

In addition to the already mentioned books the inventory of Vermeer's studio also included two Spanish chairs, a stick with an ivory knob, two easels, and three palettes. Three bundles of various prints were found, probably on the reading desk also described in the inventory. In another small room Vermeer kept five or six books, and in the attic, the inventory reads, he had a stone table and a muller to grind his pigments.

Alas, no pigments, pots, or bottles of oils are listed. Nor are water basins, in which to keep the paint from drying out, varnish bottles, or containers for turpentine. The inventoried wooden box with drawers may have contained some of his painting materials. Such boxes not only appear in many artists' self portraits, holding small pots with various liquids, brushes, and pigments, but also in depictions of painters' studios (fig. 12).

Classical sculpture and casts were common in studio interiors from the seventeenth century, but none is mentioned in the inventory. However, in the *Art of Painting* a cast of

fig. 12. Gonzales Coques, *Painter in His Studio*, oil on canvas, Staatliches Museum Schwerin

fig. 13. Johannes Vermeer, *Portrait of a Young Woman*, c. 1666–1667, oil on canvas, The Metropolitan Museum of Art, New York, Gift of Mr. and Mrs. Charles Wrightsman, in memory of Theodore Rousseau, Jr., 1979

a male face lies face-up on the table. Vermeer's maulstick is also missing in the inventory, but maybe he used the stick with an ivory knob for this purpose.

The eighteenth-century Dutch artists' biographer Arnold Houbraken (1660–1719) noted that the painter Aert de Gelder (1645–1727) had different jackets, curtains, and fabrics such as silk and satin, in his studio, which he used to clothe his model from head to foot in the way that suited his interest.[27] Vermeer's inventory includes many of the items and jackets depicted in his paintings, such as the fur-trimmed, yellow satin jacket found in six paintings. Whether Vermeer had a lay figure we do not know. However, looking at the *Portrait of a Young Woman* (fig. 13) and the anatomy of her left hand, which does not seem to fit with the foreshortening of her shoulder and arm, and the drapery over her shoulder, one gets the impression that a lay figure may have been used.[28]

The fact that Vermeer's inventory includes no frames for stretching canvas, common in many seventeenth-century studios, is very interesting. Contemporary depictions of artists' studios show them at work on canvases both strung in larger frames, often identified as the Dutch method, and tacked onto strainers (fig. 14). The paint layer does not extend over the tacking edges in any of Vermeer's paintings so far examined,[29] indicating that Vermeer preferred his canvas stretched onto its strainer before starting painting. This is corroborated by reading his inventory, in which are noted ten canvases as well as six panels standing ready to be painted.

A fine craquelure pattern running parallel to the edges of Vermeer's paintings reveals

information on the size of the original strainers that he used: they were between two-and-a-half and three-and-a-half centimeters wide. The larger strainers, such as those used for the *View of Delft* (cat. 7) and the *Art of Painting*, had central crossbars and corner braces similar to those seen in an allegorical painting by Ferdinand van Kessel (1648–1696) (figs. 15a and b).

When Vermeer started to work on a painting, we can assume that he went up to his attic in order to prepare his pigments, which, as suggested by recent analysis, were mixed with linseed oil,[30] on the stone table. Back in his studio he would be able to work on one of his two easels, the size and construction of which we can surmise from his *Art of Painting*. Vermeer probably used one of the palettes mentioned in the inventory for the lighter colors and another for the darker. We do not learn anything from the inventory about his stock of brushes, but his brushstrokes reveal that he used a number of larger square-tipped and smaller round-tipped brushes. Many brush hairs became embedded in the paint, particularly in scumbles: fine brown hairs in the half-tones in the face of the *Girl with a Pearl Earring* (cat. 15) and in the gray-brown scumble rendering the reflection of the town in the water in the *View of Delft*. In this painting also thick white hairs were found in the white underpainting of the sky.[31] The latter are presumably hog's hair and the former could be squirrel or otter hair.[32]

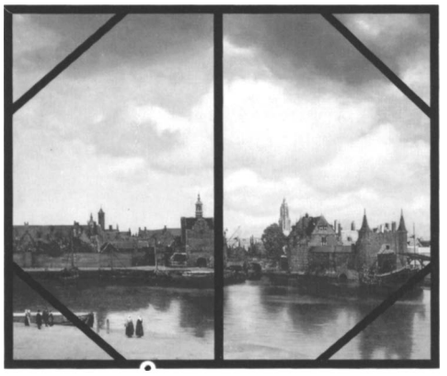
The Purchase of Materials[33]

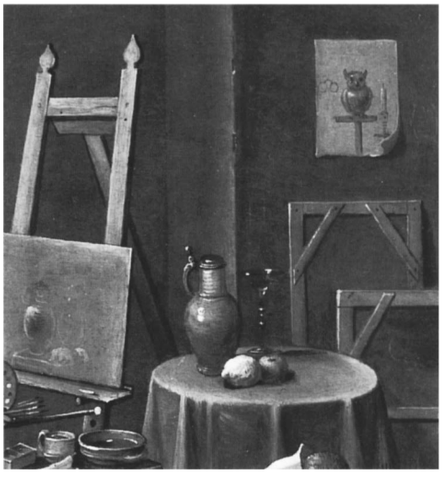
For the purchase of his materials, such as (prepared) canvases and panels and current kinds of paint, Vermeer could turn to an artists' supplier. One or more of these could

fig. 14. Vincent van der Vinne, *Painter in His Studio*, engraving, Rijksprentenkabinet, Amsterdam

LEFT: fig. 15a. Craquelure in the paint layer of the *View of Delft* indicates an original strainer as depicted in fig. 15b.

RIGHT: fig. 15b. Detail, Ferdinand van Kessel, *A Monkey Painters' Studio*, oil on copper, Courtesy R. Valls, London. The two canvases are stretched on strainers similar to the ones originally used for Vermeer's larger paintings.





probably be found in Delft, and certainly in nearby Rotterdam.[34] In the seventeenth century, Van Hoogstraeten and others advised artists not to bother trying to make pigments, which could be bought easily in various places.[35] The precious natural ultramarine that Vermeer used even in the underpainting of a number of pictures is, however, not encountered in surviving inventories of seventeenth-century artists' suppliers. For small quantities of pigments such as this, one could turn to the apothecary, the forerunner of the artists' supplier.

The inventory of the Delft apothecary D. de Cock,[36] where Vermeer had a debt for medicines,[37] lists substances that could be used for the preparation of paint and varnish. Possibly Vermeer acquired these substances from De Cock, since the massicot or lead tin yellow, listed in his inventory, was employed in many paintings, most evidently in the texture and light of the yellow satin jackets (cat. 13). Gold leaf, obtainable in small booklets, was only once applied by Vermeer, to the studs of the chair in *A Woman Asleep*. All these materials, as well as lead white, Venetian turpentine, and linseed oil, were mentioned in De Cock's inventory.

Already in the sixteenth century Delft apothecaries appear to have acquired a measure of renown for their skill in preparing pigments. The learned French physician M. de l'Obel (1538–1616) first learned from the Delft apothecary M. D. Cluyt (active in the second half of the sixteenth century) how one could make a serviceable red lacquer for the painter.[38] Not just apothecaries but also specialists involved in the production of Delft earthenware were adept in the manufacture of pigments.[39]

Vermeer's preference for the relatively expensive blue pigments such as natural ultramarine might be related to the fact that his market consisted of a small group of amateurs and connoisseurs who regularly bought work without directly commissioning it. A large proportion of the surviving works points to a single purchaser (see pages 22 and 53). The rarity of Vermeer's work has been connected with his technique: up until now it was presumed that he was a slow painter. However, brushstrokes applied wet-in-wet indicate that some parts at least were rapidly executed, although it appears that the artist may have worked on a painting at intervals. He developed a composition very carefully, sometimes

changing or deleting elements, such as the above-mentioned painting of a Cupid in *Girl Reading a Letter at an Open Window.*

A true understanding of Vermeer's painting cannot be achieved without technical data. The most fascinating is that instead of using a camera obscura, he established perspectively correct paintings, simply with the aid of a pin and strings. As previously stated, this method was also used in Vermeer's *Art of Painting*, in which the pinhole has given us a direct connection with Vermeer's own studio. In his paintings Vermeer deceives us into believing that the depicted scenes are real—according to Van Hoogstraeten this was the highest level of artistic ambition the seventeenth-century painter could aim for, a level that Vermeer surely achieved.[40]

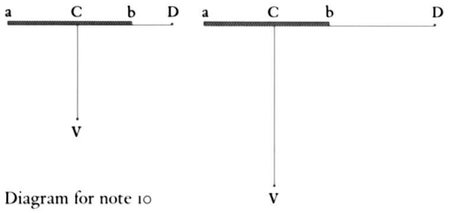


Diagram for note 10
V = View point.
C = Central vanishing point.
D = Distance point.
Distance C - D = C - V.

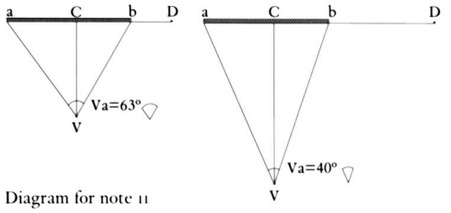


Diagram for note 11
C = Central vanishing point.
D = Distance point.
V = View point.
Va= Viewing angle.

I am indebted to Nicola Costaras and Koos Levy-van Halm for their assistance and information.

1. Van Hoogstraeten 1678, 88: "Geleertheit versiert de Schilders."
2. See Van de Wetering 1993 and Van de Wetering 1995.
3. Montias 1989, 339–344, doc. 364.
4. Vredeman de Vries 1604; Marolois 1628; Hondius 1647 and Bosse/Desargues 1664.
5. *Officer and Laughing Girl*, *The Milkmaid*, *The Glass of Wine*, *The Music Lesson*, *The Astronomer*, *The Geographer*, *Art of Painting*, *The Love Letter*, *Woman Holding a Balance*, *Lady Writing a Letter with her Maid*, *Allegory of Faith*, *A Lady Standing at the Virginal*, and *A Lady Seated at the Virginal*.
6. Hultén was the first to actually record and illustrate a discernible vanishing point in one of Vermeer's paintings (Hultén 1949, 90–98).
7. On these wall paintings, see Montias 1982, 188, 192; on Bramer, see Delft 1994.
8. Where the lead-white absorbent paint is missing, the x-rays will pass easily to the film and blacken it. In two instances there are light spots at the relevant points on the x-radiograph due to a surplus of lead white from an overlying layer that has filled the loss in the ground (in *Officer and Laughing Girl* and *Woman Holding a Balance*).
9. See Ruurs 1987, 49–50, and Jeroen Giltaij in Rotterdam 1991, 16 (a summary in Schwartz 1989, 78–82 and ill. 86).
10. The view point (V), or center of projection, is placed on the horizon at a distance from the picture plane (the canvas) equal to the distance between the central vanishing point (C) and the distance point (D). If the distance between the central vanishing point (C) and the distance point (D) is enlarged, the view point (V) also moves farther away from the picture plane.
11. In the view point (V) the viewing angle (Va) can be measured. The viewing angle is established by drawing two lines from the view point to the two vertical edges of the painting. As the distance between the painting and the view point is equal to the interval between the central vanishing point (C) and the distance point (D), it becomes clear that as the distance points move farther away from the picture, the view point (V) and the viewing angle (Va) also become smaller.
12. Ruurs 1983, 191.
13. Marolois 1628, chapters CXII-CLVII, engravings by H. Hondius.
14. See Foucart 1994, 69–70.
15. Montias 1991, 48: "extraordinaijre…curieuse…perspective" (Montias 1993, 377, doc. 325*bis).
16. For a survey of the previously published literature on this subject see Wadum 1995.
17. Wheelock 1995.
18. Van Hoogstraeten 1678, 275.
19. Arasse 1994.
20. Seymour 1964, 328.
21. Mayer-Meintschel 1978–1979, 95–96 and ill.; see also Wheelock 1987, 410–411 and ill.
22. Bosse/Desargues 1664, 9: "Turn to the surveyors, for they can teach you the rudiments of geometry and mathematics and instruct you further, nothing more, but also nothing less than that" (in translation).
23. In Bosse/Desargues 1664, 17, the following passage is found: "A large crowd of workers in various kinds of art who use three-dimensional form, such as carpenters, masons, joiners, and those who apply geometry in their work, had fully mastered it [geometry] and used it effortlessly" (in translation).
24. Ruurs 1987, 87.
25. Wijbenga 1986, 206.
26. Van Hoogstraeten 1678, 273:"zoo veel waenwijze Schilders schipbreuk lijden."
27. Houbraken 1718–1721, 3: 207.
28. One gets the same impression with Rembrandt's etched self-portrait from 1639, which shows the same pose as the *Portrait of a Woman* (see Berlin 1991, 2: 200–202, no. 13 and ill.).
29. Original tacking edges, folded over the edge of the strainer and fixed with wooden pegs or nails, are present on seventeen of the canvases examined so far.
30. See Kühn 1968; this was also confirmed by recent scientific analysis at the National Gallery of Art, Washington, and the Central Research Laboratory, Amsterdam.
31. Wadum 1994, 13–15.
32. Several theoreticians mentioned the use of these and other brushes, see Welther 1991.
33. We are indebted to Koos Levy-van Halm for this and the following important information.
34. Henny 1994.
35. Van Hoogstraeten 1678, 222.
36. Gemeentearchief, Delft, records of Notary N. Vrijenbergh, no. 2061.
37. Montias 1989, 318, doc. 297.
38. Bosman-Jelgersma 1979, 62.
39. Wijbenga 1986, 188–189.
40. Van Hoogstraeten 1678, 275.